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Abstract of a Report by Croizette Desnoyers upon that part of the Bourbonnais Railroad between St. Germain-des-Fossès and Roanne, a distance of 41 *miles.* Translated by J. BENNETT.

IT would appear from the opening of this report, that the difficulty of procuring ready information upon railroad works is felt in France as well as in the United States. It is only by visiting the works themselves, or through the special courtesy of those who superintend them, that such information can be had; it was partly to fill this gap that the author made the report of which the following is an abstract.

This road, uniting the valleys of the Allier and Loire, presents in its central portion a varied profile, calling for the construction of a great number of works, no one in particular having a marked importance above other structures of late years; for its tunnels are not so long as those of Blaisy or of Credo, nor are its viaducts comparable in height to those of Gartempe or of Chaumont; but there is a variety in the works: their dimensions, though more common in practice, are still important, and in this regard a description of them may be useful. Moreover, there are valuable facts and figures to be cited, and accidents to be mentioned, which, though unattended with serious consequences, may indicate in certain cases the precautions to be taken, and the dangers to be shunned.

With the brief statement that the works were conceded by the state to the Orleans Company, by an agreement of June, 1855; that there were two summits to be surmounted, one between the Allier and Bèbre, with a maximum grade of 42 ft. the mile, the other between the Bèbre and Loire, with a maximum of 47·5 ft.; that the minimum radius of curvature was 1640 ft.; we pass over the changes in the organization of the road, the details of its alignment, the reasons that controlled some important features in its location, and proceed with an account of its construction.

Division in Sections.—The first section is from St. Germain to Palisse, 10·8 miles.

The second from Palisse to Pacaudiere, 16·2 miles.

The third from Pacaudiere to Roanne, 14 miles.

This division corresponds with the character of the ground; the extreme sections lying mostly in the tertiary earths, the central being entirely of a granite formation.

Earthworks.—The difficulties in earthworks were also of different characters. At St. Germain the soil is very clayey, and there were many landslides, and many consolidating works; further on, the road crossed sandy clay, which, without causing massive slides, would form ravines with extreme facility, against which many precautions were taken. Beyond the Bèbre, the granitic or porphyretic soil is sometimes composed of very hard rocks, and sometimes of a more or less profound decomposed rock, known in the country by the name of *gore;* moreover, in the hardest parts there were faults filled with clay, upon which the blocks slid, causing serious accidents.

Limits of Height.—The limits of height at centre line adopted for earthwork, were from 65 to 82 ft. for excavation, and 82 to 92 ft. for embankment. These limits may evidently vary for particular cases; yet for excavating, the above named should not be surpassed, especially in steep slopes, as in that case the slope on the highest side may reach 100 ft. in vertical height; now, whatever the hardness of the rock may be, it is seldom so compact and homogeneous as to be held at that height, even upon a gentle slope, without risk; and, on the other hand, if the usual slope is adopted, the volume would be too great and the expense inadmissible. For embankments, on the contrary, such good results have been obtained from the use of decomposed granite in securing compactness and stability, that with this material, we should venture without fear upon a height of 130 ft., were it not that a viaduct would generally prove to be a more economical structure.

Profile of Embankment.—The profiles for great embankments had the usual slope of 3 base to 2 in height, and were strengthened with berms 6·5 ft. wide, at vertical distances of 19½ ft. All the earth of the lower part from the dumpings of the carts was taken up in barrows, and was spread in level layers up to 39 ft. below the top. At the commencement, these precautions were taken with all the banks; but afterwards, such was the confidence in the above named good re-

sults, the berms and rehandling were dispensed with in earths of good quality.

The increase in bulk of embankments was very considerable. Independently of the voids left by hard rocks in the banks, the gores, which were so compact as to require the pick and blasting for their excavation, were turned into coarse sand, with an increased volume; the increase in these earths was frequently $\frac{1}{7}$th.

Profile of Excavation.—In hard rock the slope was 1 in 4. In all other earth excavations, there was a berm 3 ft. wide at the foot of the slopes, which varied from 1 to 1·5 base to 1 in height. In unsolid earth there was a slope of 45°, with berms at intervals of 10 ft.; but if these berms are convenient for the flow of water, and tend to lessen defacements of the slope, they cannot well be maintained without lining; and it would be best to dispense with them by making an increased slope.

Table of Quantities of Work and Costs.

Contents.	Sec. 1.	Sec. 2.	Sec. 3.	Total.
	cub. met.	cub. met.	cub. met.	cub. met.
Contents of earth works, .	675,430	2,226,000	540,000	3,441,430
Amount per lineal metre, .	39	86	23	52
	francs.	francs.	francs	francs.
Cost including accessory works,	1,150,000	5,000,000	1,034,000	7,184,000
Cost per lineal metre, .	66	192	46	109
	f.	f.	f.	f.
Mean cost per cubic metre, .	1·70	2·21	2·03	2·10

Note.—1 cubic metre = 1·308 cubic yards. 1 franc per cubic metre = 15·29 cents per cubic yard.

The mean prices per cubic metre of the different sections do not vary so much as might have been expected in passing from the tertiary to granitic earths; this is due to the fact, that the proportion of rock to be excavated on section 2, was less than anticipated; to the less distance of haul, which at a mean was 400 metres, while it was 600 upon section 1; and to the fact, that there was but 6 per cent. of accessory works on section 2, while there was 21 per cent. on section 1.

Accessory works. Embankment over the Girauds Pond.—The road crosses many ponds, and as there had been among the first worked much expensive mucking, an attempt was made in this case to dispense with the greater portion of it. For this purpose, the muck was only taken away from the foot of each slope, and the solid earth being laid bare, two strong banks, well pugged, were raised upon it, provision being made for the flow of the central water through rubble drains. It was thought that the mud thus retained would only experience compression under the bank, and, except an unavoidable settling, that it could be constructed without accident. But in reality the mud was forced in front of the dumpings between the two ramps; so that the embankment attained the solid earth, and all the mud driven before

it had to be taken away, and the process did not succeed, though the filling was only 33 ft. high.

From this experiment and the effects in crossing other ponds, under the pressure of a bank but slightly elevated, it follows that the soft mud is displaced, and to avoid slides and disjunction it is necessary that a previous mucking be made, unless the banks are of an excellent quality; but with dry sand or rocky debris, the mud may be suffered to be forced on either side.

The Pouzoux Embankment.—The commencement of the most elevated of the embankments (92 ft. at the centre, and 108 ft. on lower slope), caused much trouble.

The earths composed of *gore* intermixed with clay, though enclosed by a bank at foot of slope, slid upon each other, so that the embankment had scarcely reached a third of its height when serious disorders were encountered. They arose solely from the filtering of spring waters issuing from the rock beneath; it sufficed to put in the middle of the bank a rubble drain 6 ft. wide, with some lateral branches, and to line the base of the lower slope with a strong enrockment let into the natural soil. Generally where slides may be expected or water is to be imprisoned, a simple pipe drainage will answer.

St. Germain Embankment.—On the St. Germain side, layers of earth from 6 to 10 ft. thick, have slid upon the core of the bank, and though replaced by good earth, well rammed and secured by checks, these new strips were again detached. There were two methods used for arresting them: 1st, by forming a sand berm at the foot of the slope; 2d, by making at intervals cuts 3 ft. deep across the slopes, and then filling them with stones. The latter method is efficacious in preserving the bank, and preventing the propagation of defacings, and is recommended; it might also be used in banks of a shifting nature. In many cases, the sand berm will answer every purpose.

Of course the above does not apply to banks of pure clay; for it should be deposited one side, and its place renewed with good borrowed earth.

Defacement of Surface.—Even when the banks are so solid as to cause no fear of slides, there may still be defacements and ravines; the latter occur frequently in granitic earths, because the decomposed rocks form a very movable sand which does not become compact with time or pressure, and because from the abrupt slopes of these earths, the waters pour down with great force and velocity. To prevent these defacements, care was taken, 1st, either by cross trenches or by linings, to keep the attacks of the water from off the foot of the slopes; 2d, by making small ramps, ·4 to ·5 ft. high, along the edge of the banks, in front of which the slopes and counter slopes conduct the water to the grass descents established at intervals of 160 ft. upon the slopes; wherever this precaution was neglected, and the berms were not maintained, ravines occurred. The existence of the berms causes some difficulty in the care of the road-bed, but they are only needed until the seed-plots and plantings upon the slopes have succeeded. In the worst earths, seed-plots of furze or broom were used

with success; grain and oats were sown, and they served to protect the broom, which, in the year following, grew thick upon the slope, and formed a good defence. In all the lower parts of great embankments, acacias were set out in a quintuncial form, 20 ins. apart.

Slides and Defacements of Slopes.—There were many slides; all that was done was to take off the extra stuff, to regulate the surface, to increase at need the inclination of the slopes, to insure the flow of water, and in most cases to line the sides; but in no case were the voids refilled, for experience proved that they would not stand fast.

Protection of the Slopes.—The favorite method of protecting the slopes was in the increase of water descent and in the leading of surface water to them by drains. Common drainage pipes are the most economical, though more expensive when laid in slopes than on a level surface, but sometimes in excavations the water is too abundant for the discharge of simple pipes; and often in decomposed granitic earths the pipes are easily choked up; in that case rubble drains are to be made; and when the earths are of a very bad quality, recourse is had to brick kennels.

The descents for drainage water are made on sods or in curved pipes; masonry descents are much more costly, and should be reserved for points with large supplies of water.

Water gutters should always be made upon the crests of excavation; sometimes these trenches receive a great supply of water, which, filtering through the section which separates it from the slope, bursts through the dyke causing more serious slides than the surface waste, which they were made to guard against. If a large volume of water comes to the crest, the ditch must be made further back or lined with masonry; in common cases a simple trench will answer.

Drainage pipes have been placed parallel to the slope at a depth of $2\frac{1}{2}$ feet below the bottom of the crest gutter, to catch the water which filters through it, and they have answered a good purpose.

Lining.—In excavation the seeding seldom succeeds without vegetable earth; there were two kinds of earth lining used: the first 6 inches, the second 12 inches thick; the first is ineffectual in clayey earth, being easily detached and succeeding only on very inclined slopes; the second worked better, though much given to sliding upon slopes of 45°, and is often nearly as expensive as an enrockment.

In sandy clay, subject to being ravined by the action of storms, soddings were effectual; they formed horizontal belts at intervals of 6 feet, with sods placed normal to the slope and one foot thick; vertical belts at intervals of $16\frac{1}{2}$ feet, and within this frame-work sodding 4 inches thick was laid flatwise; drainage tubes conducted the water in the grass descents placed at every 33 feet; thus the slope is secured, the lining is held firmly by the footing belts, and it is much less costly than if composed entirely of sods placed normal. The expense does not exceed one franc per square metre, drainage, water descents, and incidentals included.

Whenever the above linings were insufficient, an enrockment was used; rubble ditches were made $6\frac{1}{8}$ miles, $\frac{1}{3}$ the length of the total excavation.

Viaducts.

There are five viaducts constructed upon this branch; we record the differences between them, and compare them with their cost.

Palisse Viaduct over the Bèbre.—This viaduct is formed of 8 full centre arches with a span of 46 feet; its length is 545·8 feet and its height is 110 feet above the bed of river. The piers are 11·8 feet thick at the springing line, and are strengthened with counterforts terminated with battlements. The viaduct is crowned by a plinth supporting a cast iron railing over the arches and embattled parapets above the piers and abutments. The foundations are upon a hard granitic rock, and the surface is leveled with a layer of beton, which in pier 2 was $3\frac{3}{4}$ feet deep.

Its proximity to the city and great prominence called for some elegance in construction; still the piers and arches are simple and the upper part alone is ornamented. The material is handsome and cut with care, though the cut stone is restricted to the parts usually deemed essential.

The Feige Viaduct.—This viaduct is of a different construction from the above, being simple as possible, entirely formed of rubble in 8-inch courses, with no cut stone except the upper course of the plinth; at each angle chisel drafts follow the edges throughout the length.

The piers are strengthened with counterforts, whose effects give spirit to the structure, which, being entirely of a reddish brown porphyry with homogeneous faces, has a good appearance and a character of solidity, there being nothing to call off the attention from the principal lines, which stand out very distinctly.

Neither in this or the Palisse viaduct are there any belts or offsets at the springing line, the arches being an uninterrupted continuation of the piers, thus increasing the apparent height as seen from below and having a good effect.

The following dimensions are taken from the plans:

Details of Length.		Details of Height.	
7 arches, 45·92 ft.,	321·44 feet.	Pedestal of Pier 4,	17 feet.
6 piers, 11·8,	70·80 "	Shaft,	55·10 "
2 abutments, 33·45,	66·90 "	Rise of arch,	22·96 "
Total length,	459·14 "	Thickness of key,	2·62 "
		" between key and plinth,	1·64 "
		Plinth,	1·97 "
		Height above foundation,	101·29 "

Montciant Viaduct.

Details of Length.		Details of Height.	
8 arches of 39·36 feet,	314·9 feet.	Pedestal of piers,	15·42 feet.
7 piers of 9 18 feet,	64·3 "	Shaft "	44·30 "
2 abutments of 24·27 feet,	48·5 "	Rise of arches,	19·70 "
Total length,	427·7 "	Thickness of key,	2 50 "
		Between key and plinth,	1·97 "
		Plinth,	1·57 "
		Total height,	85·36 "

Cut stone is used for the belts and angles, but with small dimensions; the counterforts are suppressed and the work is reduced to the most simple form. The faces are of red granite rustic, upon which the Chevroches limestone belting-courses are drafted with good effect. The foundations are upon a hard gore from 6 to 10 feet below the natural surface. The parapet is composed of a series of cast iron bays with openings, separated by cut stone blocks at intervals of 9·84 feet. These bays, like those of the Feige viaduct, are like most of the hand-rails on the bridges of Paris, only that the size of the empty spaces were increased, for, owing to their height and the short distance from which they could be seen, they would otherwise have appeared as solid. The parapet weighs 80·4 lbs. per foot; that of the Bèbre viaduct has a less simple form and weighs 107 lbs. per foot.

Nérard Viaduct.

Details of Length.		Details of Height.	
5 arches of 55·76 feet,	278·80 feet.	Pedestal of piers, .	16·40 feet.
4 piers of 12·13 feet,	48·52 "	Shaft "	36 08 "
2 abutments of 36·40 feet,	72·80 "	Rise of arches, .	27·88 "
		Thickness of key,	2·79 "
Total length,	400·12 "	Between key and plinth,	2·13 "
		Plinth, .	1 31 "
		Total height,	86·59 "

The increased span is due to the mossy bottom of the Nérard valley, the difficulties of foundation causing a reduction in the number of piers. These foundations, which went down about 13 feet to the hard gore, called for much excavation, which had to be supported with timber on account of the many slides. The mode of construction is the same as the Monteiant, only that the dimensions of the cut stone were reduced and brought to a minimum; the counterforts might have been suppressed, as far as concerns the height, but the viaduct is built on a curve, and for ease of construction right cylindrical arches were formed resting upon piers of a trapezoidal section; the projection of the counterforts saved the straightening of the heads and avoided the breaks usually apparent in the intradoses with polygonal angles. The plinth and parapet are laid in a curve; the latter consisting of four courses of rustic masonry capped by a curved cut stone.

In all the preceding works care was taken to continue throughout the height, the batter of the heads, and counterforts, without a change at the springing line, as is frequently done, occasioning a kind of horizontal breach in the plan of the heads of the work.

The Sapin Viaduct.

Details of Length.		Details of Height.	
11 arches of 32·8 feet,	360·8 feet.	Pedestal of piers, .	21·65 feet.
2 abutment piers of 13.12 ft.,	26·24 "	Shaft "	44·77 "
8 piers of 7·55 feet, .	60·40 "	Rise of arches, .	16·40 "
2 abutments of 32·8 feet,	65·60 "	Thickness of key,	2·95 "
		Between key and plinth,	1·64 "
Total length,	513·01 "	Plinth, .	1·97 "
		Total height,	89·38 "

This viaduct differs from the others in that the arches are smaller and the thickness of the piers is not constant. The arches are separated in three groups by two abutting piers, there being five in the centre and three on each side. This arrangement gives it more of a monumental character than the preceding, while the smallness of the arches increases the apparent height. It is built of grey granite rubble, with chain courses, angles, and belts of cut limestone. The parapet is wholly of cut stone. The piers and abutments rest upon hard gore, and there were difficulties in foundations both from their depth and from bad weather.

Abutments.—In all the above-named viaducts the abutments have a rectangular horizontal section hollowed in the centre with a vertical pit of a circular or elliptic section. This arrangement guards completely against the accidents which usually follow from the use of wing walls in such works. Abutments from 50 to 66 feet high require an enormous thickness of wing walls, and the included prism of earth in storms exerts a pressure resisted with difficulty by these walls. This form of abutment was used twelve years ago in the viaducts of Indre and the Manse, but is not generally adopted in France, though there have been serious accidents in some magnificent works by defect of this precaution.

The quarter cones of abutments have inclinations varying from 45° to 1½ base for 1 in height. Those of 45° give rise to landslides, even with enrockment at the base, and it is best to have an inclination of 1½ or 1¼ at the least. When the extreme piers are partially covered by these quarter cones, it is well to support them by counterforts.

Prices.	Viaducts.					Average
	Bèbre.	Montciant.	Nérard	Feige.	Sapins	
	francs	francs.	francs.	francs.	francs.	francs.
Cost per linear metre, .	4159	2548	2977	2917	3165	3195
" per square metre in elevation,	165	125	133	119	137	137
" per cubic metre of masonry,	45	34	34	31	36	36

Note. 1 franc per linear metre = 18·28 cents per linear yard.
1 " square do. = 16·72 " square "
1 " cubic do. = 15·29 " cubic "

It is seen that the Bèbre viaduct is the most costly, the Sapin the next, and that the three others do not differ widely.

The Montciant, Nérard, and Sapin viaducts are nearly of the same height, and in good condition for comparison, and it appears that their respective prices per linear metre, have nearly the same proportion as the price per superficial metre; the conclusion, then, derived from these three adopted types, is that the most economical is the one which has arches of 39 ft. span; the next in order is that with spans of 55 feet, and the most costly is that with 33 ft. span. Too small arches evidently have this disadvantage, that the surface of the lateral faces of piers increases with the number of the arches much more than they

are diminished in surfaces of elevation; but, on the other hand, when certain limits of span are exceeded, we require more costly centerings and materials, and increased thicknesses; thus the span of from 39 to 46 ft. appears to be the most preferable in the conditions of our viaducts, and they are most generally adopted by engineers for similar heights.

In comparing the superficial metre in elevation, the price is seen to range from 119 to 165 francs, or reducing the last limit to a comparable rate of elementary cost, from 119 to 150 francs; so that between the adoption of the different types, the expense may vary $\frac{1}{5}$th, a consideration prompting the use of the most economical dispositions, though there may be local exigencies which may justify a departure from them.

The use of very hard granite rubble justifies the differences in the cost of these viaducts and those recently constructed upon other lines at a cost of 100 francs per superficial metre; with limestone rubble the price would have been reduced on the Feige viaduct from 103 to 104 francs.

It is believed, then, that if a viaduct from 98 to 115 ft. high can be built of limestone for 100 francs per superficial metre, for hard granite the price should be raised from 115 to 120 francs; it is admitted also, that with granite rubble and cut limestone, a simple viaduct, like the Monteiant and Nérard, would cost in general from 10 to 15 francs more per metre than a work wholly in rubble, and this difference would lead to a preference for the last type, especially when the effect is as satisfactory.

Surfaces and Cubes.—

	Bèbre.	Monteiant.	Nérard	Feige.	Sapins.	Average.
Ratio of the voids to full spaces (surface in elevation), . .	1·78	1·76	1·48	1·60	1·56	1·64
Cube per superficial metre in elevation, .	3·67	3·62	3·83	3·86	3·86	3·78

The ratio of the void to the full surface is less than in the viaduct of Chaumont (3·12), and a little below that of the Dinan viaduct (2·06), because, all else being equal, the ratio increases with the height of the works; thus, for example, though the Bèbre and Feige viaducts have arches of the same openings and piers of the same thickness, the ratio varies from 1·78 to 1·60, because the latter of these works is less elevated and shorter.

The cubic metres corresponding to the surface metres in elevation, vary but little for the five works, because, though it might seem as if there should be a constant width for works of the same road, and the cubes consequently follow the ratio of the full parts to the voids, yet it must be remembered that the widths are only the same at the summit, that by reason of the battre the mean widths increase with the

height, and the increase is the greater as counterforts are used beyond a certain height, and consequently the increase in width compensates very closely for the reduction resulting from the value of the ratio between the empty and the full.

We give a table showing an apportionment of the cost of the viaducts.

Cost per Superficial Metre in Elevation.	Viaducts.					Average.
	Bèbre.	Montciant.	Nérard.	Feige.	Sapins.	
	francs.	francs.	francs.	francs.	francs.	francs.
Foundations, . .	14·80	5 90	13·90	8·80	13·30	11·50
Piers and abutments up to springing line, .	77 20	58·10	49·00	57·80	69·30	63 60
From springing line to plinth, . .	47 40	41·30	49·00	34·90	38·80	42·10
Plinths and parapets, .	17·30	12 30	9·90	11·20	12·40	12·80
Centres, . . .	8·30	7·40	11·20	6·30	3 20	7·00
Totals, . .	165·00	125 00	133·00	119·00	137·00	137·00

For the piers and abutments up to the springing line, the expense increases naturally with the height and number of the piers; for the part between the springing line and plinth, it follows an inverse proportion; with these general inferences we make no further comment upon the table, believing that the previous statements of the character of the work will account sufficiently for the existing differences of cost.

Pressures.—

Portions subjected to Pressure.	Pressure in kil. per sq. centim. for viaducts.*					Average.
	Bèbre.	Montciant.	Nérard.	Feige.	Sapins	
	kil.	kil.	kil.	kil.	kil.	kil.
At summit of pier shaft, .	4·51	4·60	5·37	4·51	4·70	4·74
At base of pier on pedestal,	6·92	6·18	6·58	6·32	5 20	6 24
At base of pedestal, .	6 07	6 96	6·12	5·24	4·80	5·84
Upon bottom of foundation,	6·07	6 66	5·82	4·73	3·70	5·40

* 1 kilogramme per square centimetre = 14·229 lbs. per square inch.

The greatest pressures are in accordance with the different types; they are comprised between 5·20 kil. and 6·96 kil., or 74 lbs. to 99 lbs. per square inch. In the plans, 99·6 lbs. per square inch was taken for the limit. This limit has been exceeded in other similar constructions, and it may be thought that the masonry was too thick; but it must be remembered that the interior of the piers, instead of having blocks with parallel beds, as for the viaduct of Dinan, or the great works of the Limoges line, were simply of rough rubble, quite irregular, which, from their hard granitic character, offered smooth and un-

adhesive surfaces to the mortar; the leveled courses of rubble used were spaced far apart (15 ft. according to plan), and were few in number. An increased thickness thus compensated for these unfavorable conditions. With easily cut stone there may be an advantage in constructing piers with regular courses, but in general as there is no great call for restricting masonry to the minimum thickness, there is a marked economy in building the interior of rough stone. A work with dimensions a little beyond the strict limits of stability, creates confidence, and has a more satisfactory appearance.

The pressures upon the bottom of foundation did not exceed 94·77 lbs. to the square inch; this might have been exceeded upon the Bèbre viaduct, which was upon hard rock; but the other viaducts rested upon decomposed granite, whose hardness varied in the same pit, and it was not deemed prudent to increase the load.

Scaffolding.—For the construction of the piers there were two systems of scaffolding; the first, for the viaduct of Bèbre, was composed of a continuous service bridge connected with vertical frames entirely surrounding each pier. The service bridge abutted upon a hill, on the side of which an inclined iron rail track served for raising the materials to the level of the service bridge, while another track upon the bridge conducted them to the axis of the pier for which they were designed; at this point they were taken by a car furnished with a windlass, and moving lengthwise of the pier, so that the stone is readily lodged where it belongs. The frames of the piers, as well as the uprights supporting the service bridge, were at the first set at their full height; but in order that the materials should not be hoisted higher than necessary, the service bridge was secured to the uprights by bolts, thus allowing it to be raised with the advance of the work; the shifting was effected in a few hours, and generally on Sundays, to prevent any interruption of the work. The service bridge of the Bèbre viaduct had siding tracks, which, though generally answering the purpose, were at times obstructed, so that it would be best to lay a double track, as but little increasing the expense.

The second system, that of the Monteiant viaduct, was composed of isolated scaffoldings for each pier. The frames were similar to those of the other system, and also had a double moving truck with windlass which raised the stones from the surface of the ground.

The first system is of course more costly in its establishment than the second, but the excess seems to be largely compensated in the diminution of the cost of raising materials and the greater facility it offers for their disposal. A disadvantage in the second system is its liability of obstructing the piers with materials, while the workmen are often kept idle from not finding among them such as they may need. At the Bèbre viaduct the cars were loaded at the ends of the service bridge or upon the sidings, and were not brought to the piers until the moment when they were required, and the stones and mortar were distributed upon either pier without obstructing the masons or causing them to be brought to a stand still. These advantages caused their adoption on the three viaducts last constructed.

This system would not be directly applicable upon a work of great length or where the abutments do not adjoin a hill-side; in that case there should be established a few points with special appliances for hoisting, with a place for the deposit of materials at their summit, from whence they may be distributed by the system already described.

For the Feige viaduct, on account of the small size of material, the service bridge became simply a foot bridge, and the frames around the piers were suppressed, as all the stones were carried and laid by hand. This simplification of scaffolding is one of the great advantages belonging to the use of small stone.

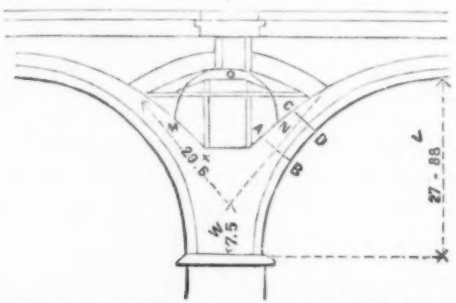
For the construction of the arches, a service bridge was built upon the centres with movable cranes.

Time used in Building.—In works of this kind we cannot hasten the construction indefinitely, especially in the rearing of the piers, because the working limits are much restricted. At the Bèbre viaduct from the 30th of April to the 31st of August, or in 120 days, they raised 47 courses of shafts and laid 4 voussoirs upon all the piers, which gives as a mean $2\frac{1}{3}$ days for each course; in pier No. 4, which was behind-hand for some time, 18 courses were laid in $1\frac{1}{2}$ days only; from the finishing of the shaft till the construction of the arches, 40 days were consumed in raising the centres and installing upon them a service bridge with cranes; the arches were afterwards closed in 40 days.

It was supposed that with rubble masonry the piers might be constructed more rapidly, but the workmen say that though rubble is easier to handle, yet it requires more time to lay two courses of angle rubble than a single similar one of cut stone, and in reality, though the work was hastened, as a mean there were but five courses of rubble laid per week, which answers for $2\frac{3}{5}$ days for one course of cut stone; so that the construction entirely in rubble does not seem to present any advantage in respect to rapidity of execution.

Discharge Arches of the Nérard Viaduct.—The spandrils of all the viaducts were to have been filled with sand béton, but for the Nérard, as the season was far advanced, and the volume of béton required considerable, it was thought that time might be saved in building discharge

Fig. 1.



arches upon the haunches of the great arches, which might also answer as supports for the service bridge required for the transportation of earth in the winter. The expense was not materially different for

either case. Arches were therefore built according to the figure (1). As the small centre was to be used in another spandril, it was taken down six days after the turning of the discharge arch, while the mortar was yet green, and the great arches themselves but recently constructed. The small arch settled from 3 to 4 inches, and exerted against the flanks of the large arches a pressure so that the archivault was driven inwards from $\frac{6}{10}$ to $\frac{8}{10}$ inch to the right of the small arch, so as to open the joints of the extrados in the directions A B, C D. This accident was due to the incomplete setting of the mortar, but shows also that the small arch was too much surbased, and exerted its thrust at points too distant from the springing line. It would be well then, in such cases, to adopt for the curve of intrados the line M O N. The centerings of the other small arches not having been taken down till after the winter, no settlement occurred, nor was there any appreciable effect upon the haunches of the great arches.

Accidents in Uncentering.—In the Nérard and Feige viaducts, owing to bad management in uncentering, the heads were thrust one side at the intrados, though no fissure appeared at the extrados. It is probable that the joints of rubble in contact with the heads, not being well squared, in the different settlings occasioned by irregular uncenterings, exerted an oblique thrust, which forced the heads outwards. The openings of the joints were from $\frac{4}{10}$ to $\frac{6}{10}$ inch. This separation is more easily explained in the Nérard viaduct, whose heads were of cut stone and the remainder of rubble, than in the Feige, whose materials were homogeneous. The joints were repaired, and not the least fissure has since occurred; still, as the arches of the Nérard were large they were secured with iron tie-rods. This accident, though not serious, shows that too much attention cannot be given to taking down of centres, even in full centred arches of small span, and with agents who have successfully executed similar but more difficult works.

Mortars.—In the foundations and lower parts of the viaducts, the eminently hydraulic lime of Joze was used. It always gave good results, but its rapid setting caused it to be unfit for great heights with slow processes of hoisting. At first it was replaced by a mean hydraulic lime of Cusset mixed with Auvergne puzzolano and sand; more lately good results were obtained from the use of decomposed porphyry mixed as sand with the mean hydraulic lime. There would have been great economy if they had ventured to use it from the start, but it was thought imprudent until new proofs should corroborate the good results of previous trials; besides setting quickly, it was requisite that its hardness should increase with time, so that the experiments required a long period to be conclusive. The gore or decomposed porphyry gives out a coarse argillaceous sand, and is in reality a kind of puzzolano; an analysis of it was made at the École des Ponts et Chaussées, and its puzzolano qualities were recognised.

An account of the tunnels, sustaining walls, culverts, &c., will be given in the next paper.

(To be Continued.)

*Observations on the Niagara Bridge.**† By PETER W. BARLOW, Esq., C.E., F.R.S., F.G.S., &c., &c.

As remarked by Mr. Roebling in his very able report to the President and Directors of the Bridge Company in 1855, "one single observation of the passage of a train will convince the most sceptical that the practicability of suspended railway bridges, so much doubted heretofore, has been successfully demonstrated."

On my first arrival there several trains passed over. I placed my eye on a level with the platform, standing off the bridge, but neither wave nor vibration were perceptible to the naked eye. I then stood on the road platform of the bridge, and afterwards on the upper or railway platform, and found no more vibration or undulation (although the road, from the wear of the rails, is out of condition) than is felt in an ordinary suspension bridge from a horse walking over.

If the advocates or admirers of girders or tubes imagine that their mode of construction is free from vibration, they are presuming on a fact of which they will discover the error by standing on a tube or girder while a train passes over it. A train passing even on solid ground over a bad road will cause a sensible vibration in a house at 50 or even 100 yards from a railway.

The idea of a structure free from vibration is therefore imaginary, and inconsistent with the constitution of matter. The question for the practical man alone is the avoidance of such a degree of momentum by vibration or undulation as will produce a strain beyond the limit of the elasticity of the material.

This simple and evident proposition has been generally disregarded by the constructors of suspension bridges, as the platforms have been made, as before observed, without any regard to vertical stiffening; the result of which, in a gale of wind, is a degree of undulation by which strains are produced (judging from the depth of the reported undulations in some cases) equal to five or six times that due to the simple weight on the bridge. No kind of structure is proof against such treatment; and it is more a matter of surprise that they should last so long, than they should frequently fail.

On my second visit to the Niagara Bridge, I observed the deflection, by means of a level, from the passage of an ordinary passenger train, to be ·41 of a foot, which of course includes the amount of wave plus the deflection from the elongation of the cable. The train, which consisted of two American cars, 50 feet long, besides the van and locomotive, I estimated to weigh 80 tons, and the deflection from the actual elongation of the cable to be ·182 of a foot. It is clear, therefore, that the amount of wave, or distortion of the cable from its original figure, does not amount to three inches in a length of 821 feet; a change of figure which, occurring gradually during the progress of a train, does not approach an amount of disturbance sufficient to produce momentum. And it is evident to me that no suspension bridge has

* And on the practicability of connecting Liverpool and Birkenhead, and New York and Brooklyn, by wire suspension bridges of one span; also, remarks on street railways and the application of the suspension principle to correct the inconveniences of the London street traffic; and a suggestion for a viaduct across the Holborn valley, and across the Mersey at Runcorn.

† From the London Engineer, No. 253.

failed from any undulation produced by a passing load, but either from actual insufficiency of section of metal in the cables, or from undulation produced by the action of a hurricane.

The papers published in Vol. III of the "Transactions of the Institute of Civil Engineers," by General Pasley, R.E., on the Montrose Bridge after a hurricane in October, 1838, and by John Provis, Esq., C.E., on the injury to the Menai Bridge in 1839, give valuable information on the effect of wind on suspension bridges.

Mr. Provis and General Pasley both agree in the opinion that the injurious action principally arises from the undulation of the platform, and not from the vibration or oscillation of the chains; and the remedy applied by Mr. Provis was an increase given in the longitudinal stiffness of the platform, which, although not to such extent as my calculations would deem necessary, has been found sufficient to cure the evil, as no further damage has occurred since 1839.

Mr. Provis states in his report that the amount of wave of a previous gale of wind in 1836 was observed by the bridge-keeper to be 16 feet, and there is no doubt the wave of the gale of 1839, which caused the principal damage (which was most severe in the night) was much greater. It therefore might reasonably have been expected that the cables which sustained the succession of blows arising from the momentum of a platform (the total weight of which was 400 tons) falling 16 feet would have sustained injury, and these not being injured, is a proof that this bridge, with a properly constructed metal girder and platform, could be used safely for railway traffic, as the heaviest train on a good road would create less momentum than that produced by the undulation described.

In the Niagara Bridge the injurious action of the wind is amply guarded against. The undulatory action on the platform at the highest calculation will not exceed the weight of a heavy goods train, and as the timber trussing (which is 18 feet deep) is proved to have such girder resistance, that a train will not produce a wave exceeding 3 or 4 inches, there is no fear of an injury from the effect of a hurricane, but to be doubly sure, Mr. Roebling has added 56 wire-rope stays, attached to the lower floor, which are firmly anchored to the solid rock.

These rope stays have been treated in the arguments used against the success of the Niagara Bridge, as forming part of the structure, and as adding to the rigidity; but this is clearly not the case, at all events in the hot season, because the platform of the bridge is lowered above two feet by the expansion, and as the stays will be at the same time lengthened, they will be so loosened as to be inoperative at the period when the greatest traffic occurs. The experiment made by me was in the commencement of August, when the temperature was unusually high even for America, and when they could by no possibility have had any influence on the rigidity.

It is also frequently argued as a proof of the instability of the Niagara Bridge, that its weakness is tacitly acknowleged by the regulations of the engineer, which limit the speed of trains to five miles an hour.

It has been a debated question whether greater deflection in a girder arises from increased speed, and this subject was particularly investigated by the commissioners appointed, in 1849, to inquire into the application of iron to railway structures, and some experiments were made by me at their desire, on the Godstone Bridge of the South-Eastern Railway, of which I was at that time the resident engineer. A scaffold was erected which rested on the road, and was, therefore, unaffected by the motion of the bridge, and a pencil was fixed to the underside of one of the girders of the bridge, so that when the latter was affected by the weight of the engine or train, either placed at rest or passing over it, the pencil traced the extent of the deflection on a drawing board attached to the scaffold. The commissioners report "that the deflection was slightly but decidedly increased when the engine was made to pass over the bridge, and at a velocity of about 50 miles per hour an increase of one-seventh was observed. As it is known that the strain upon a girder is nearly proportional to the deflection, it must be inferred that in this case the velocity of the load enabled it to exercise the same pressure as if it had been increased by one-seventh, and placed at rest upon the centre of the bridge."

Assuming such result to arise from increased speed, there is no reason for not running at 50 miles per hour over the Niagara Bridge, as the heaviest train that can be placed on it does not produce, with the weight of the bridge, a strain equal to $\frac{1}{6}$-th per cent. of the ultimate strength of the cables.

Being of course present at these experiments, and having recorded some of the observations referred to, I formed the opinion, which was concurred with at the time by other engineers, that the increased deflection principally arose from imperfection of the joints, the engine falling through a certain space at each bad joint, and thus producing a blow.

And I have little doubt, if the stability of the structure was the only question, that, if a good fished permanent way was laid over the Niagara Bridge, no more vibration and deflection would be produced at a speed of 50 miles per hour, than now occurs on the present road, which, although perfectly safe, is much worn by the heavy traffic.

But the speed which may be safely adopted in passing a bridge is not a simple question depending alone on the rigidity and strength of the structure. A train may run off the road at a high speed, either from the state of the permanent way or the fracture of an axle or any part of the rolling stock, and every description of girder in such a case would fail. No person who has witnessed a railway accident, and the effect of a collision, will doubt that, under such circumstances, the sides of a tube or lattice girder (on which the stability, as well as on the top and bottom, depend) would be carried away.

And here it may be remarked that a misunderstanding frequently exists as to the momentum of a train in relation to the speed. The mechanical definition of momentum is weight multiplied into velocity, from which it may be supposed that a train at double speed would exert only double the force on any object it came in contact with; but

this is not so. It would require four times the amount of brake power, and would tear away four times the extent of the sides of a lattice or tube girder, to bring it to a state of rest, and therefore the danger from such an accident increases in a rapid ratio in relation to the speed.

As a general rule, such an accident on a suspension bridge would be less fatal, because it is dependent on the sides of the girder for stiffness only, and not for its actual strength. It appears to me, however, that no bridge, whatever its construction, is safe if a train leaves the road at 50 miles per hour, and that in a bridge situated as at Niagara over a chasm 240 feet deep, it is a wise precaution to travel slowly, particularly as little can be gained by increased speed, there being a station immediately on each side of the river, at which every train stops.

In concluding my remarks on the reason of the engineer for adopting an unusually slow speed on the Niagara Bridge, and how far it is to be considered as an acknowledgment on his part of deficiency of strength in the structure, it should be mentioned that it is the customary practice in the United States (inconsistent as it may appear to their supposed disregard of life) not to permit even a single horse to go beyond a walking pace over their road bridges, whatever may be their construction, and a penalty of five dollars is rigidly enforced for any disregard of the rule. I passed over girder, arched, as well as suspension bridges, and found no exception in the rule; and a notice-board is generally put up, as at Niagara, to warn the drivers of the penalty.

Such being the custom of the country, it is imperative on Mr. Roebling to adopt it in a bridge situated as at Niagara; but it cannot be supposed (as between forty and fifty engines cross the bridge every day, and a train of 350 tons with two engines has passed over) that the engineer is afraid to trot a horse over it, and adopts this rule from a fear of the safety of his bridge. And it is, no doubt, under similar circumstances that he adopts the slow speed over his rails as well as over his road.

It appears, therefore, that any impression as to the insecurity of the Niagara Bridge, induced from the caution used by Mr. Roebling in a railway bridge of such extent and in such a situation, is a very unfair one, as the same rules would have been adopted by every American engineer if the bridge had been of half the extent, with no difficulty or novelty in the construction.

On the Strength of the Niagara Bridge.

The bridge is supported by four cables, each containing 60·40 square inches, the two upper of which have a deflection of 54 feet, and the lower pair 64 feet. The strain at the points of support, in relation to the weight, will be obtained as follows:

Let d represent the deflection,
W the weight,
S the half span,
and T the tension.

$$T = \frac{W}{4\,d}\sqrt{4 \times d^2 + s^2}, \text{ or,}$$

The cables having different deflections, the strain with a given weight

will vary in each pair of cables, which is undoubtedly a defect in the bridge; because in the summer the lower pair will do the principal duty, and in winter the upper pair. There is, however, such an abundance of strength, that no strain can ever arise on either cable that approaches the limit of elasticity, that the mean deflection of 59 feet will fairly represent the average strain on the cables.

$$\text{Therefore } T = \frac{W}{4 \times 59} \sqrt{4 \times 59^2 + 410{\cdot}66^2} = 1{\cdot}81.$$

The total weight between the towers is estimated by Mr. Roebling at 1000 tons, and therefore the strain on the cables from the bridge alone will be 1810 tons. The ultimate strength of the four cables is estimated from actual tests of each wire at 11,904 tons.* The ratio of strength to the ordinary strain will, therefore, be as 6·5 to 1, and the strain per square inch of iron wire, 7·5 tons.

The strength of the iron, being 100,000 lbs. per square inch, as estimated by the engineer, is unusually high; but it is arrived at by actual test, and the metal was of the best quality, as will be seen by reference to the specification.† The capability of manufacturing iron to resist tensile strains, of such superior quality to that used for girders, produces one of the practical advantages of the suspension principle, by reducing the weight of the structure, which in large spans causes the principal strain they have to contend with.

As the weight of the bridge is limited by regulation to 300 tons, the greatest strain on the cables, including the weight of the bridge itself, will not exceed 2380 tons, or under one-fifth of the ultimate strength of the cables, and therefore it is fully of the strength required by the officers of the Board of Trade of this country for railway bridges.

On the Durability of the Niagara Suspension Bridge.

This, like every railway bridge in England, has been subjected to the test of a load exceeding what it can be subjected to in practice; there is, therefore, a margin in every bridge for deterioration of a determined amount, being the difference between the actual test of the bridge and the greatest load it will afterwards receive.

But this is not the only security as to durability. In addition to the margin obtained by actual experiment, there is a much greater intended margin, the security of which as an actual test of strength depends on calculation; that is to say, the ultimate strength of the structure is intended to be much greater than the test applied; and in the case of the Niagara, is estimated to be equal to endure a strain of five times the test applied, including the weight of the bridge itself.

In comparing the durability of railway structures, the certainty of the calculation on which this margin depends is an important element in the question.

With regard to the actual deterioration from oxidation, the progress

* The wire was manufactured by Messrs. Johnsons, of Manchester, England.

† See report of Mr. Roebling, C.E., 1856, in "Public Works, British and American," published by John Weale, 59 High Holborn.

is so slow that its operation in a suspension bridge, where every part can be got at and painted, will not be an appreciable amount. Tube bridges, or any structures composed of thin plates, and cells difficult to be got at, will be more liable to loss of strength from this cause.

Another supposed cause of decay in the strength of iron structures, is the alteration in the mechanical conditions of the fibres of the metal from continual vibration. There is no doubt that violent and continuous vibration of iron will affect its tensile strength after a length of time, but it is clear that it must be of a very severe character to produce any injurious result, because the parts of machinery of various kinds, and none more so than a marine steam engine, have to endure an amount of constant vibration which would soon exhibit itself if iron was readily affected. That steel wire will bear violent vibration without injury is proved by the durability of musical instruments, and the existence of suspension bridges constructed without girders for so many years, in which the most severe vibration occurs in every gale of wind (as is so forcibly described in the report of General Pasley and Mr. Provis), satisfies me that, in a structure like the Niagara Bridge, where the cables are subjected to a moderate tension, and may be said to be free from vibration, their durability will not be less than the masonry of which the towers are built.

In large girders, which are admitted to be of necessity much heavier, and of their own weight to create a larger constant strain on the metal, the destruction will be more rapid. But the feature in girder constructions which to my mind renders their durability doubtful, is the fact that they depend for their strength and safety on the compressive, as well as the tensile resistance of iron, and consequently the estimated margin of strength is more doubtful, because the power of a bar to resist compression is not always correctly measured, as in a tension bar, by the section of metal. As long as a compression bar or tube maintains its figure, its power of resistance is in proportion to the section; but when you have large girders to deal with, and serious compressive strains, no calculation derived from model experiments is to be depended on; an engineer cannot be certain that a few tons in excess of his actual test will not cause buckling and the destruction of the bridge, and therefore there does not exist in girders or arches that certainty of durability that exists in a properly constructed suspension bridge.

Before concluding my observations on the Niagara Bridge, it is necessary to say a few words on its imperfections as well as its good qualities. I have before referred to the two cables having a different amount of deflection, which it appears has arisen from its having been designed in the first instance for road traffic alone. The effect of this is, that the deflection from expansion will be different in the two cables; and thus the principal work is done in the winter by the upper cable, and in the summer by the lower cable. This difference, which amounts to about 2 inches, is not sufficient to bring any serious strain on the cables, but it is calculated to cause an irregularity in the weight on the suspension rods, which may possibly lead to a little inconvenience.

A second objection is, the use of timber for the longitudinal trussing and flooring. It is objectionable from presenting more surface to the action of the wind, but more particularly from much greater weight of material being required to gain a given longitudinal stiffness. Fir timber of a given weight will extend or compress 2·5 times the amount of a similar weight of good wrought iron, although the specific gravity is as 1 to 10; and the parts of an iron truss or girder admit of being secured together so as to retain a larger proportion of the action of the fibres than is the case with wood.

A suspension bridge should have the platform or roadway also of iron, so as to act as a horizontal girder and resist the action of the wind. By the use of iron in the platform and girders, a weight of 400 tons in the place of 600 tons of timber would have reduced the deflection of the wave to one-third, and would have rendered unnecessary any anchorage to prevent the action af the wind.*

A third and final objection applies to nearly all suspension bridges, hitherto constructed, viz., the cables are supported on carriages on rollers, instead of being attached to the towers.

An engineer, when he constructs an arch, would not expect to have a rigid structure if he placed the abutment on rollers, and how can he expect in a suspension bridge to have rigidity if he adopts a similar expedient?

We are apt to follow what has been previously adopted without reflection, and desire to avoid the responsibility of a change of an adopted system; but there is no difficulty in attaching the cables to the towers if they are of iron, and constructed so as to act as vertical girders, to resist the inequality of the weight which may arise on the different spans of a bridge. In fact, you cannot expect perfect rigidity in a suspension bridge as they are now constructed; but there is no reason why they should not be treated like an arch reversed; and if they were so treated there is nothing in the suspension principle to render them less rigid.

There is, however, no intention to imply, by these observations, that the Niagara Bridge is less durable from these omissions to any appreciable extent. I believe, provided the timber and masonry are kept in repair, it will last for hundreds of years, and that a certain degree of motion in a bridge does not affect its strength or durability, provided no strain in any part exceeding the elasticity is produced; at the same time, by the means pointed out, the undulation and vibration, small as it is, would be considerably reduced.†

(To be Continued.)

*The towers should also be of iron, in order that the expansion may correspond with that of the suspension rods. The suspension rods should be at right angles to the cables, and fewer in number, by which the tremor as well as the undulation will be reduced.

†See the report of Mr. Roebling, C.E., in the *Engineer*, September 21, 1860, and *Jour. Frank. Inst.*, vol. xl., Dec., 1860., p. 361.

Query respecting Suspension Bridges.

To the Editor of the Journal of the Franklin Institute.

SIR:—I may be mistaken (and if so, shall be glad to have my error corrected) in believing that the design for a suspension bridge of four

spans of one thousand feet each, and two spans of five hundred feet each, which I prepared early in the year 1851 immediately after my return from the Panama Railroad, and which was exhibited for several months of that year in the reading-room of your Institute, was the first proposition for applying that principle to railroad purposes on a large scale. The design (which is fresh in the memories of many visitors at your rooms) was prepared with the object of showing the practicability of uniting the Philadelphia and Columbia Railroad of Pennsylvania with the Camden and Amboy Railroad of New Jersey by crossing the River Delaware at Market Street, Philadelphia, without either obstructing the navigation of the river, or incurring an excessive expense. The entrance to the bridge on the Philadelphia side was at Second Street; and the floor was placed 100 feet above high water, so that the few large vessels which ascend above Market Street could pass with ease by striking their top-gallant masts; a very simple operation requiring but a few minutes to perform. The rigidity of the bridge was provided for on the same general principle as in the Niagara Suspension Bridge built since that time; namely, by strong timber trussing about twenty feet deep, put together on the system well known as the, so-called, Burr's plan, but omitting the wooden arches. The entire design was very much the same as I should now adopt if called on to plan such a bridge. My drawing was also placed in your annual exhibition of 1851; and was afterwards removed to the public room of the Merchants Exchange, where it remained for several months; and from which it was taken during my absence in South America engaged in the exploration of Humboldt's proposed interoceanic canal routes in 1852. It elicited one or two notices in the newspapers of the day; but was very generally regarded as a chimerical proposition. I have never been able to ascertain by whom it was removed. If this notice should meet the eye of any person acquainted with its present whereabouts, he will confer a favor by informing me of it.

JOHN C. TRAUTWINE.

Philadelphia, Dec. 7, 1860.

MECHANICS, PHYSICS, AND CHEMISTRY.

For the Journal of the Franklin Institute.

Alloys of Cadmium. By B. WOOD, M. D.

In a former communication,* I took occasion to speak in general terms of some of the properties of cadmium as exhibited in combination with other metals, in order to draw attention to certain characteristics which appeared to have been overlooked heretofore. I now propose to speak of some of its specific combinations by way of illustrating its properties in particular connexions. I confine myself to the results of my own experiments.

These experiments were made at different periods, as occasion

* Journal of the Franklin Institute for August, 1860, page 113.

prompted, with a view to the production of alloys possessing properties suitable for particular uses. Although they cannot but fall short in value to what a more methodical investigation might have educed, it is hoped they may not be altogether without interest.

Cadmium in its general characters has a greater resemblance to tin than to other metals. It has less lustre, tarnishes more readily in the atmosphere, is considerably harder, and requires a higher heat for its fusion. It has a sort of milk-white glistening color, approaching a silver-white, with a blue tinge, somewhat like zinc. Its melting point is nearly the same as that of lead. At a low red heat it volatilizes, giving off orange-colored fumes; at a higher heat it flashes and detonates, and if the heat be still raised it bursts into flame with an explosion. It is perfectly malleable, and has considerable tenacity.* In flexibility or toughness, or coherence of its particles, as indicated by flexion and torsion,† it is inferior to tin, ranking with lead. It dissolves rapidly in nitric acid, is acted on feebly by muriatic acid, and very slightly by sulphuric acid. (Neither of the last named acids evinced a perceptible action immediately; after remaining some hours in strong muriatic acid, the metal became blackened, small bubbles (hydrogen) clinging to the surface, and a minute quantity of black particles being detached from it; immersed the same length of time in sulphuric acid, the surface of the metal was not perceptibly discolored, though slightly clouded, presenting a "deadened" appearance; no bubbles were visible.)

It tarnishes at once in strong solution of caustic potash, but the *solvent* action of this menstruum upon it appears to be very feeble.

Electrically, it is highly positive with respect to gold and silver. When pieces of gold and cadmium, placed on opposite sides of the tongue, are brought in contact in the usual method, a powerful galvanic action results, producing a remarkably pungent, disagreeable, and persistent taste, with a sense of excoriation of the tongue and even lips. The impression produced by cadmium and silver in the same way, is also very pungent, but the taste is not so disagreeable.

With some metals, cadmium appears to have little affinity; with others, its affinity is very strong.

Its volatility renders its combination with the less fusible metals somewhat difficult under ordinary circumstances, although probably not in general more so than is the case with zinc.

Cadmium and *Copper* have too little affinity to alloy well. It is difficult to make them unite by means of the blow-pipe;‡ the process

* Phillips, Manual of Metallurgy, ranges it in the order of malleability, below tin, but above lead; in ductility below both. I do not remember having seen its tenacity indicated. What I mean by "perfect," as applied to malleability, is that the metal is susceptible of being hammered down to thin plates without any cracks or breaks at the edges.

† I am at a loss for a good term to denote this quality, or the amount of flexion which metals in the form of bars are enabled to endure before breaking. The flexibility or toughness of the following metals, as indicated by bending at right angles back and forth, is represented by the order in which they are named, to wit: 1. Tin (the most flexible of metals); 2, Gold (pure); 3, Platinum; 4, Cadmium and Lead; 5, Silver; 6, Copper; 7, Zinc.

‡ The experiments detailed in the present paper were made with the common blow-pipe, upon a charcoal support, using borax to promote union, and to prevent volatilization of cadmium. As a further precaution against volatilization, the cadmium should be kept a little separate from the other metal (or alloy), directing the jet of flame at first upon the latter until melted, or at least heated to redness, which in most cases will suffice, when the two are to be brought quickly in contact.

must be managed with care; it is generally attended with crackling, and much volatilization of cadmium. If copper be used in excess, the alloy is likely to be porous or cavernous, presenting a spongy structure, owing to the retention of vaporized particles of cadmium which refused to enter into combination. On remelting the compound, a portion of the cadmium volatilizes and extricates itself, bubbling up through the fused mass, and on this again cooling and solidifying, jagged protrusions break through the crust, like scoria. So, too, if brought to a red heat, though not melted, a portion of the cadmium oozes out and escapes in fumes. When, however, cadmium is in excess, the union is more intimate and perfect, the structure of the alloy being compact throughout.

3 parts (by weight) of cadmium and 1 part copper, form a white, brittle alloy, of compact and homogeneous structure. It breaks like glass at a tap of the hammer, with a pearl-like fracture, presenting smooth glistening facets of a very clear white color, resembling very nearly the fractured surface of antimony, but surpassing it in brilliancy. Upon exposure to the atmosphere, its surface acquires a yellow tinge. It melts at a red heat, or at about the melting point of antimony.

1 part cadmium, 1 copper.—A brittle, yellowish-white alloy, breaks under a light blow with a granular fracture. Upon exposure, the surface assumes a deep yellow color.

1 cadmium, 2 to 4 copper. The metals in these proportions combine imperfectly under the blow-pipe. The compounds are brittle or but slightly malleable, and have a red copperish color.

Cadmium and *Platinum* combine at a full red heat, with a sort of explosion (?). It was difficult to form this alloy with the blow-pipe. The cadmium fumed, crackled, and burned, in spite of any management; and when combination took place, the percussion was such as to blow the mass from the support. Melted in a crucible under borax, there was a slight detonation, but no combustion or fumes.

1 cadmium, 1 platinum, form a hard, brittle alloy, breaking at a tap of the hammer with a crystalline fracture, of a gray color, having a purplish tint resembling bismuth.

1 cadmium, 3 platinum: similar to the last in character and appearance, but still more brittle, shattering to fragments under a slight blow. It has a clear gray color, and a higher metallic lustre than the preceding.

Cadmium and *Nickel.* With nickel I could not effect a combination, the metals appearing to have no affinity whatever, the cadmium burning away, and the nickel not the least affected.

Tin and nickel under the same circumstances combine, forming an iron-gray brittle compound.

Cadmium and *Silver* unite readily by the blow-pipe, with little tendency on the part of the cadmium to volatilize; showing a strong affinity between the metals.

1 cadmium, 1 silver (pure), form a gray-white alloy, of the color of platinum with a violet shade. It is very hard to the knife. It has a

firm homogeneous texture. In hammering, it evinces considerable malleability, but is disposed to cleave under repeated blows. If annealed during the process, it is highly malleable. When condensed by hammering, it breaks easily, presenting a close-grained fracture; but when previously annealed, it bears flexion back and forth nearly as well as copper.

2 cadmium, 1 silver. Very hard, superior to zinc in this respect. Color bluish-gray similar to that of zinc, but has more lustre. Not malleable, cracking through the centre with a coarse fracture.

1 cadmium, 2 silver. This is also a very hard alloy, apparently harder than the last mentioned. It has a yellowish-white color, with a beautiful violet hue. It is perfectly malleable, and has great tenacity. The difficulty with which it fuses is remarkable, particularly in view of the common theory as to the fusibility of alloys. Tested by the side of ordinary silver solder on silver plate, it did not melt under the heat which flowed the solder, and only when the silver began to melt. It is nearly tasteless.

2 cadmium, 3 silver. Similar to the last in general characters, but in color approximates more to a true yellow.

Cadmium, *Silver*, and *Tin*. Alloys consisting of 1 cadmium, 2 silver, 4 tin; and 2 cadmium, 1 silver, 2 tin, are hard, malleable, and possess considerable tenacity.

Cadmium and *Gold* combine perfectly and with remarkable readiness. Properly managed, the union takes place without hissing, crackling, or detonation (as I was led to anticipate from the cases of copper and platinum), and the cadmium shows no disposition to escape by volatilization. The affinity of these metals is extraordinary. No sooner is the cadmium brought in contact with the melted gold than the metals seem literally to leap into each other's embrace, blending instantly into a homogeneous compound. Their compounds appear to fuse at a temperature less than the mean of the melting point of the constituents.

1 cadmium, 2 gold (pure), unite perfectly and with great facility (as above described), forming a splendent round button; color, white with a yellow tinge. Very hard to the knife. Not malleable, breaking through the centre with a crystalline fracture.

The alloys with gold continue brittle until the cadmium is reduced to one-eighth part or less.

1 cadmium, 9 gold. This is of a greenish-yellow or brass color. Very malleable if annealed during the process of hammering. In toughness or flexibility similar to copper. Its fusibility is nearly the same as ordinary 18 carat gold.

Cadmium, *Gold*, and *Silver*. The addition of silver to alloys of gold and cadmium increases their malleability, but diminishes their fusibility.

1 cadmium, 9 gold, 2 silver. In color this resembles the last named, although somewhat paler. It is perfectly malleable, hammering out thin, with smooth, unbroken edges. It is infusible at the melting point of 20 carat gold, but melts and flows on pure gold. It will be

observed that this and the preceding case furnish results different from what generally holds good in respect to gold alloys, the fusibility of which is usually increased by lowering the standard of fineness, and also, the standard remaining the same, by multiplying the number of constituents, especially when each of these is less fusible than gold. Thus, 18 carat gold melts more easily than 20 carat, and 16 carat more easily than 18. Again, gold of the same standard, say 18 carat, is more fusible when alloyed with both silver and copper than when alloyed with but one of these metals. But the alloy last described, although both lower in standard and having a greater number of constituents than the one preceding it, requires a much higher heat for its fusion.

Cadmium, *Gold*, and *Copper*. The compounds of these metals are interesting on account of their fusibility; the most decided effect, other qualities considered, being produced when nearly equal proportions of copper and cadmium are used in the combination with gold. It is worthy of note that, whereas silver added to compounds of cadmium and gold raises the melting point, copper, although less fusible than silver, lowers it.

1 part cadmium, 4 copper, 25 gold (bringing the gold to the standard of 20 carat), form a very malleable alloy, of a tawny copper color. It is but little more fusible than 20 carat gold alloyed with copper and silver.

1 cadmium, 1 copper, 10 gold (equal to 20 carat gold). An orange colored alloy; hard, malleable, and tenacious. It has a pungent, disagreeable, "brassy" taste. It melts and flows with facility on 16 carat gold solder, and also on silver plate; but is less fusible than silver solder. In practice, it is required for safe working that gold solder (alloyed with copper and silver in proportions insuring the greatest fusibility) should be at least 4 carats below the standard of the gold on which it is to be worked. But the reverse holds in the examples just cited, even when the same constituents are used, if only used in different proportions.

The melting point of the alloy is further lowered by reducing the proportion of gold, but this impairs the qualities of malleability and tenacity.

Equal parts of cadmium, copper, and gold, produce a silver-white, brittle alloy, which cleaves asunder under a smart blow, presenting a granular fracture. It melts below a red heat, a little above the melting point of zinc, but below that of antimony.

Cadmium, *Gold*, *Copper*, and *Silver*. Silver added to combinations of cadmium, gold, and copper, promotes tenacity and diminishes fusibility, but less decidedly than in the case of compounds of gold and cadmium. By varying the proportions of these four metals, the different varieties of gold color may be imitated.

1 cadmium, 1 copper, 2 silver, 20 gold (fineness 20 carats). A bright "yellow-gold" color. Perfectly malleable. Much less fusible than ordinary 20 carat gold.

1 cadmium, 2 copper, 1 silver (20 carat). Color nearly that of pure gold. Malleable. Somewhat more fusible than 20 carat gold.

1 cadmium, 1 copper, 2 silver, 12 gold (18 carat). Very malleable. A rich yellow color. Similar in fusibility to the last.

1 cadmium, 2 copper, 1 silver, 12 gold (18 carat). Malleable. Nearly a pure gold color. Melts readily on gold solder. Barely melts on silver plate. This is somewhat less fusible than gold alloyed to 20 carat standard by the use of equal parts of cadmium and copper. It is liable to the same objection of having a "brassy taste"—a characteristic which appertains to all alloys of gold, no matter how fine, which contain both cadmium and copper.

The quantity of gold may be further reduced in the above formulæ without perceptible damage in respect to color.

Cadmium, *Copper*, and *Silver*. It is curious to observe the rich and varied colors exhibited by the different combinations of these metals.

In their physical properties these alloys are all hard. If silver, or silver and copper, be in excess, they are malleable. If cadmium, or cadmium and copper, be much in excess, they are brittle. But in either case, they have greater malleability than might have been expected, judging from the brittleness of the mixtures of cadmium and copper. We witness here the remarkable effect of silver as a bond of affinity between these two metals, in promoting their union and changing the character of the joint result.

Equal parts cadmium, copper, and silver, unite readily with very little volatilization of cadmium. The alloy is harder than that of equal parts of silver and cadmium, and nearly the same or somewhat superior in malleability and tenacity, being highly malleable and possessing considerable strength. It has a pale, pinkish-yellow color. If cadmium be somewhat in excess, the malleability is impaired, and the color approaches more to violet.

1 cadmium, 1 copper, 2 silver. Combination takes place with facility. A very handsome alloy, compact in texture. Perfectly malleable, and has great tenacity, resembling in these respects the alloy consisting of 1 part cadmium, and 2 parts silver. Color, yellowish-white, with a golden hue.

1 cadmium, 2 copper, 1 silver. These proportions do not combine so readily as in the two preceding cases. In respect to malleability and tenacity, the alloy is somewhat inferior to the first named, but superior to the last. Color, pale copperish-red, or pink. An alloy of 1 cadmium, 3 copper, 2 silver, has a redder color, but is very similar in other qualities.

5 cadmium, 3 copper, 4 silver. This is but slightly malleable. It possesses a fine lilac color.

2 cadmium, 1 copper, 3 silver. Perfectly malleable. Color, a beautiful light violet.

3 cadmium, 1 copper, 2 silver. But slightly malleable. It has a very rich violet color.

Thus it appears, by different proportions of these metals, we produce all the richer tints of the rainbow—the various combinations of violet, yellow, red. These alloys admit of a high polish, and,

doubtless, some of them would prove valuable substitutes for silver, for certain uses.

In these descriptions, it has appeared necessary to deal with specific proportions, in a variety of forms. We cannot rely upon generalization, nor upon what is predicated upon single instances, as to the behavior and products of metals in combination with others. Descriptions not based upon any specific formula convey little or no positive information, and may lead into error. When but a single formula is given, or if, when none is given, we are to take equivalent proportions as being intended, the facts frequently show, at every considerable departure on either side from the formula given or intended, results essentially different from those described.

In another paper, I propose to speak of some of the combinations of cadmium with the softer metals.

Nashville, Nov. 24, 1860.

Electric Zincing: Process of MM. PERSON and SIRE.

In one hundred parts of water, dissolve 10 parts of alum and one part of oxide of zinc; this is the zincing bath, and it is well to keep it at 15°. The pieces which it is designed to zinc, being first cleansed, are so arranged as to constitute the negative pole of a pile; at the positive pole, are piled one or two sheets of zinc, having the form of the pieces to be zinced, and about the same dimensions. The poles of the pile thus disposed are plunged into the alum bath. By the action of a current of a single element, whose size increases with the size of the pieces to be zinced, the reduction of the zinc is accomplished as easily as that of copper in galvano-plating, and its deposit takes place indifferently on all metals, as well upon platina as on copper or iron.

When the zinced copper is heated, a coating of brass is formed, and this may receive various applications. Raising the temperature of the zinced iron increases the adhesion of the coating of zinc. MM. Person and Sire affirm that the thickness of the coating increases proportionally to the time: that the reduced zinc has all the properties of the purest zinc, and that it completely prevents the oxidation of the object covered with it.—*Cosmos*, November, 1860.

For the Journal of the Franklin Institute.

Particulars of the U. S. Steamer Dacotah.

This vessel was one of the seven second-class sloops recently built by the Government.

The hull was built at the Navy Yard, Norfolk, from the design of the late Samuel T. Hartt.

The engines were constructed by Messrs. Murray and Hazzlehurst, of Baltimore. The contract for the machinery required a speed of 14 miles per hour with an additional compensation for a speed of 15 sta-

tute miles per hour for six consecutive hours. The following are the principal dimensions:

HULL.—Length between perpendiculars, 198 ft. 6 ins. Do. for tonnage, 227 ft. Extreme breadth, 32 ft. 9 ins. Depth of hold, 9 ft. 3½ ins. Draft of water, 13 ft. Tonnage, 1150 46-95 tons. Displacement at above draft, 1368·74 ft. Area of immersed section, 365 sq. ft. Do load water line, 2663 sq. ft.

ENGINES.—Two horizontal geared engines. Diameter of cylinder, 5 ft. 3 ins. Length of stroke, 3 ft. Diameter of crank shaft, 1 ft 1 in. Do. of screw do., 10¼ ins. Do. of spur wheel, 8 ft. Do. of pinion, 3 ft. 6 ins. Proportion of gearing, 2·23 to 1. Maximum pressure of steam, 35 lbs. Do. revolutions, 35.

The engines are fitted with independent steam and exhaust slide valves. The expansion of steam is effected by the link motion, which is regulated by an adjustable attachment.

Two surface condensers. Number of tubes in each, 2856. External diameter of do., ⅝-in. Length of do., 4 ft Thickness of tube-sheets, 1 in. Diameter of air pump, 1 ft. 8 ins. Length of stroke, 3 ft.

Two air pumps double-acting, one side being used for fresh water and the other side salt water. The steam is condensed upon the outside of the tubes. One end of the tubes is made fast, the other passing freely through the other sheet, but is packed with gum washes according to the patent of William Sewell, Esq.

BOILERS.—Two.—Horizontal tubular. Length of boilers, 10 ft. 6 ins. Breadth of do., 24 ft. 6 ins. Height do., exclusive of steam chimney, 10 ft. 3 ins. Do., inclusive of do., 14 ft. 3 ins. Total number of furnaces, 16. Width of eight do., 2 ft. 10 ins. Do., 1 ft. 10 ins. Length of grates, 6 ft. 4 ins. Number of tubes, 896. External diameter of do., 3 ins. Length of do., 7 ft. 6 ins. Total grate surface, 268 sq. ft. Do. heating surface, 6800 sq ft. Steam room, 1300 cub. ft. Diameter of smoke pipe, 7 ft. Height of do. above grates, 41 ft.

PROPELLER.—Diameter, 12 ft. 6 ins. Length at hub, 2 ft. Do. at periphery, 2 ft. 3 ins. Number of blades, 3.

At the hub the pitch is that of a true screw of 17 feet pitch. At the periphery the pitch expands from 17 to 19 feet.

Although the engines are geared they are not above the water line —the centres of the spur wheel and pinion being in the horizontal line through the centre of the cylinder. This is accomplished by making the after connecting-rod in two parts—separated to allow the shaft to pass through and permit the vibration of the rod with the revolution of the crank.

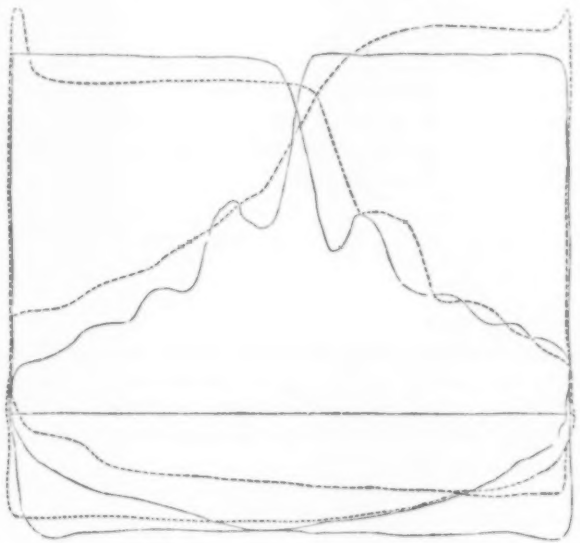
The eccentrics work upon a shaft separate and above the crank shaft, to which motion is communicated by means of gearing. The screw shaft passing through the dead wood is covered with brass and is fitted with lignum vitæ bearings. The shaft is fitted with a cone thrust and the ordinary collar thrust.

The bunkers stow 240 tons of coal. The weight of machinery, spars, and water in boilers, &c., is 277·76 tons.

In accordance with the contract, the vessel passed a satisfactory trial at sea for one week, and during four consecutive hours maintained a speed of 13·2 knots or 15·24 statute miles per hour. The following

is a specimen of indicator diagrams taken at the above speed. Date May 30th, 1860, 2 hours 30 minutes, P. M.

	After Engine. (full lines.)	Forward Engine. (dotted lines.)
Revolutions per minute,	35	35
Pressure of steam,	32	32
Vacuum,	25	25·5
Throttle,	Wide open.	Wide open.
Mean pressure,	29·16	28·8
Horse power,	578·43	571·29



An abstract from her log shows a consumption of 2·81 lbs. of coal per hour per horse power. The contract specified that the consumption should not exceed 2·9 lbs.

Armament.—Two 11-inch pivot guns and four 32-pounder guns.

The *Dacotah* is now attached to the squadron for the East Indies and China Seas. J. H. W.

For the Journal of the Franklin Institute.

Power required to Overcome the Resistance of the Feed Pumps of the U. S. S. Frigate Powhatan. By Wm. H. Shock, Chief Engineer, U. S. Navy.

I was anxious to ascertain with some degree of certainty the amount of power required to overcome the resistance of the feed pumps of the *Powhatan*, and, as preliminary to that investigation, the annexed plate of diagrams was taken under different conditions of the check valves on the boilers, as follows:

Check valves wide open.
" at usual working point.
" close shut.

I deemed these three points sufficient for the investigation, thinking that any deviation from them in practice would not materially modify

the result. In this I was correct, as will be seen upon examination of the diagrams, and the tabulated H. P. deduced therefrom.

The average pressure of steam, revolutions, &c., &c., were taken from the daily engine diagrams, and were as follows:

Steam per gauge,	11½ lbs.
Revolutions per minute,	9·3 "
Vacuum,	25 inches.
Hot-well,	120°

DIMENSIONS OF PUMPS, &c.

Diameter of pumps,	8 inches.
Stroke of "	42 "
Diameter (internal) of feed pipes,	4¼ "
Weight on safety feed valve,	294 lbs.
Pressure per square inch on safety feed valve,	20·7 "

From diagrams 1, 2, 3, &c., Plate I, it is found that the power necessary to overcome resistance of feed pumps was as follows:*

No. 1 = 1·12	horse powers.	
" 2 = 1·19	"	
" 3 = 1·58	"	} Check valves at their usual
" 4 = 1·48	"	} working lift.
" 5 = 1·73	"	
" 6 = 1·54	"	
Mean, 1·44	"	

As the investigation was to ascertain more particularly the power absorbed by the pumps under their normal working condition, we shall use those diagrams only which were taken at that time, and assume their mean resistance to be the measure of power absorbed by each pump, as follows:

No. 3 = 1·58	H. P.
" 4 = 1·48	"
C = 1·52	"
D = 1·70	"
Mean, 1·57	"

And $1{\cdot}57 \times 4 = 6{\cdot}28$ H. P. as the total resistance of the four pumps. The engines at the time were developing 527·58 H. P., 6·28, or 1·19 per centum, of which was being absorbed by the feed pumps.

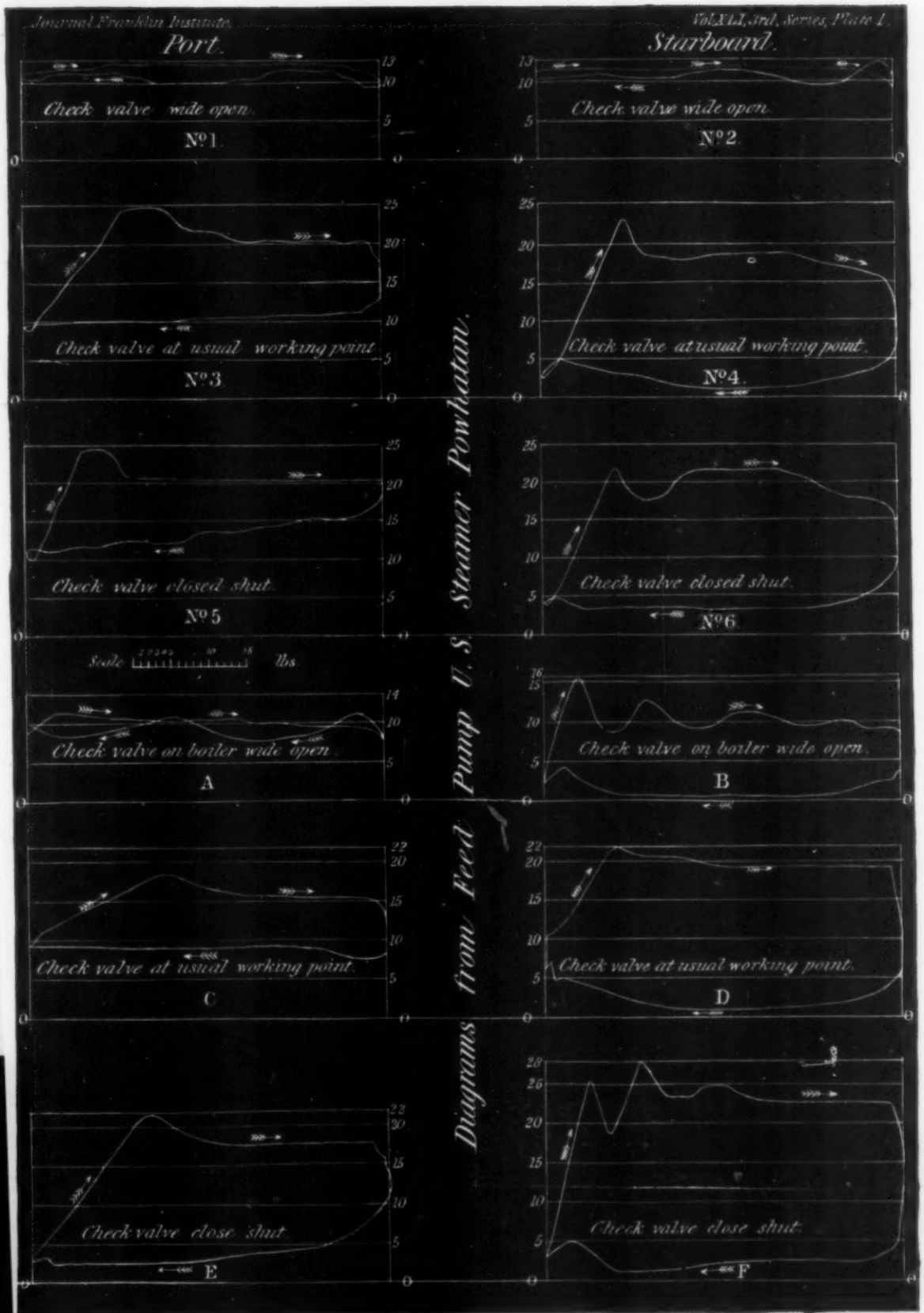
Diagrams A, B, C, &c., were taken under nearly the same conditions of steam, revolutions, &c., &c.

The following tabulated statement shows the pump resistance as determined by each diagram on that day:*

A = 1·23	horse powers.	
B = 1·26	"	
C = 1·52	"	} Check valves at their usual
D = 1·70	"	} working lift.
E = 1·58	"	
F = 1·91	"	
Mean, 1·53	"	

When Plate of diagrams A, B, C, &c., was taken, the engines were developing 600 horse powers, 1·045 per centum of which was exhausted in overcoming the resistance of the pumps.

* It will be observed that the *friction* resistance of the pump plungers, is not an element in the above calculations, not because it was of no importance, but simply from the fact that it was impossible to arrive at a correct estimate of its value. In properly managed pumps, however, loss from this source would be comparatively small.


Diagrams from Feed Pump U.S. Steamer Powhatan.
Port.
Starboard.
Check valve wide open.
No 1.
Check valve wide open.
No 2.
Check valve at usual working point.
No 3
Check valve at usual working point.
No 4.
Check valve closed shut.
No 5
Check valve closed shut.
No 6.
Scale
lbs.
Check valve on boiler wide open.
A
Check valve on boiler wide open.
B
Check valve at usual working point.
C
Check valve at usual working point.
D
Check valve close shut.
E
Check valve close shut.
F

Mean, 1 53 "

When Plate of diagrams A, B, C, &c., was taken, the engines were developing 600 horse powers, 1·045 per centum of which was exhausted in overcoming the resistance of the pumps.

* It will be observed that the *friction* resistance of the pump plungers, is not an element in the above calculations, not because it was of no importance, but simply from the fact that it was impossible to arrive at a correct estimate of its value. In properly managed pumps, however, loss from this source would be comparatively small.

Results of Experiments on the Tensile Strength of Copper, Iron, Gun Metal, Yellow Metal, and Bolts. Made at the U. S. Navy Yard, Washington, D. C., by Wm. M. Ellis, Engineer and Machinist. Tabulated and Reduced by C. H. Haswell.

No. of Test.	Material.	Diameter.	Length.	Reduction of diameter.	Extension of length.	Breaking Weight.	Mean Strength.	Cohesive strength per sq. inch.
		Inch.	Feet.	Inch.	Inch.	lbs.		
1	Copper.		3		1	10,400		
2	"		3		1	12,100	11,900	38,567
3	"		3			13,200		
1	"		3			15,700		
2	"		3			18,100	17,600	39,820
3	"		3			19,000		
1	"	1	3			29,900		
2	"	1	3			29,700	29,700	37,834
3	"	1	3			29,500		
1	"	1	3			26,400		
2	"	1	3			32,400	29,600	29,780
3	"	1	3			30,000		
1	"	1	2			41,000		
2	"	1	2			41,500	41,833	34,093
3	"	1	2			43,000		
1	Iron.		3	1-16	4	16,800		
2	"		3		4·5	17,300	17,066	55,590
3	"		3		4·5	17,100		
1	"		3		1·75	21,500		
2	"		3			24,100	24,500	55,429
3	"		3	1-16		27,900		
1	"	1	3		5·5	43,100		
2	"	1	3			39,900	41,533	52,908
3	"	1	3			41,600		
1	"	1	3			44,000		
2	"	1	3			50,000	44,866	45,136
3	"	1	3			40,600		
1	"	1	2	1-16	2·5	62,600		
2	"	1	2			64,200	64,200	52,322
3	"	1	2			65,800		
1	*Gun metal.	1	3			15,300		
2	"	1	3			11,800	13,550	17,388
1	†Yellow metal.		3		3	15,000		
2	"		3			16,500	15,750	51,302
1	"		3	9-16	3	25,800		
2	"		3			21,500	23,000	52,036
3	"		3			21,700		
1	"	1	3		9	44,500		
2	"	1	3			38,800	40,500	51,460
3	"	1	3			38,200		
1	"	1	3			45,800		
2	"	1	3			41,400	43,600	43,883
1	"	1	2	1-16	3	58,200		
2	"	1	2			46,200	55,066	44,878
3	"	1	2	3-16		60,800		

* 9 Copper, 1 Tin.
† " "

Mean results of above, { Copper, 36,000 lbs. / Iron, 52,250 " / Gun metal, 17,400 " / Yellow metal, 48,700 "

For the Journal of the Franklin Institute.

On the Breaking Weight of Iron.

Hodgkinson, in his valuable work on cast iron, published in 1846, gives the following formula for calculating the breaking loads in tons of solid cast iron cylindrical columns, with flat ends; and not less than 30 diameters in height or length,

$$42\,2\,\frac{d^{3\cdot6}}{L^{1\cdot7}},$$

and in the Philosophical Transactions of the Royal Society, Part 2, 1840, he gives for similar columns of wrought iron,

$$133\,\frac{d^{3\cdot6}}{L^{2}}.$$

In both cases, the diameter, d, is in inches; and the length, L, in feet. In the last, indeed, he uses $d^{3\cdot55}$ instead of $d^{3\cdot6}$; and 133·75 instead of 133. The foregoing substitutions, however, do not affect the results to any important extent. From these two formulæ I have calculated the two following sets of breaking loads in tons for columns 3 inches in diameter.

Length in Feet.	Cast Iron.	Wrought Iron.
	Tons.	Tons.
8	67·2	108·
10	46·	69·4
12	33·8	48·2
14	26·	35·4
16	20·7	27·1
18	16·9	21·4
20	14·2	17·3
22	12·	14·3
24	10·4	12·
26	9·1	10·2
28	8·	8·84
30	7·1	7·71

Now, Mr. Hodgkinson tells us in his work on cast iron, that in *long* columns (by which he means those which are 30 diameters, or more, in height), wrought iron is stronger than cast in the proportion of $1\frac{3}{4}$ to 1; and this is reiterated in all our modern books on the strength of materials, in order that unlettered practical men, like myself, may at once obtain the strength of a wrought iron column from a table of cast iron ones, by merely adding 75 per cent. to the latter. But you will perceive that no such proportion exhibits itself in the foregoing calculations. Again, in the *Civil Engineer and Architect's Journal*, vol. 9, page 308, year 1846 (the same in which Mr. Hodgkinson's work on cast iron appeared), he says that in *long* columns, wrought iron is stronger than cast as 5 to 1·4. Now, the range between $1\frac{3}{4}$ to 1, and 5 to 1·4, is a tolerably wide one for the best authority we have on the subject, and scarcely definite enough for even a practical

man; but unfortunately neither of these proportions is even approximately borne out by the calculations. This, however, is probably my own fault, owing to some misconception on the subject, which I have not the requisite knowledge to correct.

Professor Rankine tells us in his "Applied Mechanics," that at 60 diameters in height, wrought iron columns have twice the strength of cast; and at 80 diameters, 2½ times; making the ratio in favor of wrought iron to increase with the length, which is undoubtedly correct. But the ratio of strengths in the foregoing columns of my table becomes less favorable to wrought iron as the height increases. Thus, at 15 feet or 60 diameters, we have 32 to 23; at 20 feet or 80 diameters, 17 to 14; and at 30 feet or 120 diameters, 7·7 to 7·1.

By reference to the volume of the Philosophical Transactions before alluded to, I see that Mr. Hodgkinson tried but two experiments on plain solid wrought iron columns of the kind of which I am speaking, namely:

Length in inches.	Length in feet.	Diameter in inches.	Breaking weight in pounds.
90¾	7·563	1 02	5280
60½	5 042	1 02	12990

and on applying his formula, I find that it agrees exceedingly well with these two results: a natural consequence of its having been based upon them.

Since the introduction of both cast and wrought iron in buildings and in bridges is now becoming very general in the United States, it is essential that our practical men should have the results of the most reliable experiments laid before them in a simple form adapted to their purposes and comprehensions. It is under that plea that I ask the insertion of this crude communication in your valuable *Journal*, in the hope that it may enlist the interest of some one of your scientific readers, and induce him to relieve not only myself, but many others, from the embarrassment in which our ignorance on this important subject involves us. Writers possessed of the high mathematical attainments which distinguish Mr. Hodgkinson, and render him so pre-eminently qualified to investigate so difficult a subject, frequently make too little allowance for the more restricted powers of the very class of men to which their conclusions would be most useful; and therefore express their results in a language which, although very clear to persons of like qualifications to their own, is an unknown tongue to those of more limited requirements, like myself. I take it for granted that my difficulty in the present instance arises from this source alone.

To save as much trouble as possible to any one who may have the kindness to look into this matter and set me right, I add a few of the preliminary calculations as I employed them.

$d^{3·6}$ power of 1·02 is 1·074.

" of 3· is 52·2.

L$^{1\cdot7}$ power of	8	ft. is	34·3	L$^{1\cdot7}$ power of	20	ft. is	162·8
"	10	"	50·12	"	22	"	191·5
"	12	"	68·33	"	24	"	222·
"	14	"	88·8	"	26	"	254·3
"	16	"	111·4	"	28	"	288·5
"	18	"	136·1	"	30	"	324·4

And, $7\cdot563^2$ feet $= 57\cdot2$. $5\cdot042^2 = 25\cdot4$. J.

Gas Generators.

The November number of the *London, Edinburgh, and Dublin Philosophical Magazine* contains an account of a bungling imitation of Hare's self-regulating reservoir for hydrogen and other gases by a G. Gore, Esq.

Hare's apparatus, which is a modification of one invented by Gay-Lussac, is almost indispensable in any working laboratory and is remarkable for its neatness, simplicity, and cheapness. We have never seen it noticed in any European work on Chemistry, although when Döbereiner invented his hydrogen lamp, he showed his knowledge of it, by appropriating it without acknowledgment. Mr. Gore appears to have attempted the farther step of modifying it, as Clark did (in the same spirit) his blow-pipe; and the same result has been obtained, that is, a manifestly unfair apparatus. F.

The Magnetic Water Gauge.

The *Civil Engineer and Architect's Journal* for November reproduces at some length and with evident marks of approbation the magnetic water gauge claimed as the invention of one M. Pinel, of Rouen. But in fact the instrument is the invention of Mr. Faber of this country, and will be found described in this *Journal* as early as March, 1851 (vol. xxii, 3rd series, p. 215).

The variation from Faber by M. Pinel renders the instrument less delicate and useful—for as it consists in producing a vertical rectilineal motion in the index, this can be of course only as great as that of the water level itself; whereas Mr. Faber's index rotates, and the arc described by its extremity will be greater as the index is longer. M. Pinel is also compelled to pass the rod carrying his magnet through a stuffing-box so as to avoid the action of the steam and foam on his magnet, causing it to stick to the sides of its tube. But in Mr. Faber's invention, which has been so largely practically in use for so many years, the motion is rotary and the magnet lies in the steam space itself.

The claims of Mr. Faber have been recognised by English Engineers at the meetings of their Institutes, why then should their magazines persist in endeavoring to ignore the claims of a prior inventor? F.

See our remarks upon the laudation of this same gauge by the Abbè Moigno, May, 1855, vol. xxix, 3d series, page 350.

For the Journal of the Franklin Institute.

Strength of Materials: Deduced from the latest experiments of Barlow, Buchanan, Fairbairn, Hodgkinson, Stephenson, Major Wade, U. S. Ordnance Corps, and others. By CHAS. H. HASWELL, Civil and Marine Engineer.

No. 3.

(Continued from page 391, vol. xl.)

To ascertain the Transverse Strength of a Rectangular Bar or Beam.

When a Bar or Beam is Fixed at one End, and Loaded at the other.

RULE.—Multiply the *Value* of the material in the preceding tables, or as ascertained, by the breadth, and square of the depth, in inches, and divide the product by the length in feet; the quotient is the result in pounds.

NOTE.—When the beam is loaded uniformly throughout its length, the result must be doubled.

EXAMPLE.—What are the weights each that a cast and a wrought iron bar, 2 inches square and projecting 30 inches in length, will bear without permanent injury?

The *values* for cast and wrought iron in this and the following calculations, are assumed to be 250 and 200.

Hence, $250 \times 2 \times 2^2 = 2000$, *which,* $\div 2{\cdot}5 = 800$ *lbs.*
$200 \times 2 \times 2^2 = 1600$, *which,* $\div 2{\cdot}5 = 640$ *lbs.*

OR, *If the Dimensions of a Bar or Beam be required to Support a Given Weight at its End.*

RULE.—Divide the product of the weight and the length in feet, by the *Value* of the material, and the quotient will give the product of the breadth and the square of the depth of the bar or beam.

EXAMPLE.—What is the depth of a wrought iron beam, 2 inches broad, necessary to support 640 lbs. suspended at 30 inches from the fixed end?

$\frac{640 \times 2{\cdot}5}{200} = 8$, *which,* $\div 2$ *ins. for the breadth,* $= 4$, and $\sqrt{4} = 2$ *the depth required in inches.*

When a Bar or Beam is Fixed at both Ends, and Loaded in the Middle.

RULE.—Multiply the *Value* of the material in the preceding tables, or as ascertained, by six times the breadth, and the square of the depth, in inches, and divide the product by the length in feet, the quotient is the result in pounds.

NOTE.—When the beam is loaded uniformly throughout its length, the result must be doubled.

EXAMPLE.—What weight will a bar of cast iron, 2 inches square and 5 feet in length, support in the middle, without permanent injury?

$250 \times 2 \times 6 \times 2^2 = 12{,}000$, *which,* $\div 5 = 2400$ *lbs.*

OR, *If the Dimensions of a Bar or Beam are required to Support a Given Weight in the Middle, between the Fixed Ends.*

RULE.—Divide the product of the weight and the length in feet, by six times the *Value* of the material, and the quotient will give the product of the breadth, and the square of the depth of the bar or beam.

EXAMPLE.—What dimensions will a cast iron bar, 5 feet in length, require to support without permanent injury, a stress of 2400 lbs.?

$\frac{2400 \times 5}{250 \times 6} = \frac{12000}{1500} = 8$, *which,* $\div 2$ *ins. for the assumed breadth,* $= 4$, and $\sqrt{4} = 2 =$ *the depth required in inches.*

When the Breadth or Depth is required.

Divide the product obtained by the preceding rules by the square of the depth, and the quotient is the breadth; or by the breadth, and the square root of the quotient is the depth.

ILLUSTRATION.—If 128 is the product, and the depth is 8:

Then, $128 \div 8^2 = 2$, *the breadth.*

Also, $128 \div 2 = 64 = 8$, *the depth.*

When the Weight is not in the Middle between the Ends.

RULE.—Multiply the *Value* in the preceding table, or as ascertained, by three times the length in feet, and the breadth and square of the depth, in inches, and divide the product by twice the product of the distances of the weight, or stress from either end.

EXAMPLE.—What is the weight a cast iron bar, fixed at both ends, 2 inches square and 5 feet in length, will bear without permanent injury, 2 feet from one end?

$$\frac{250 \times 3 \times 5 \times 2 \times 2^2}{2 \times 2 \times 3} = \frac{30{,}000}{12} = 2500 \text{ lbs.}$$

When a Bar or Beam is Supported at both Ends, and Loaded in the Middle.

RULE.—Multiply the *Value* of the material in the preceding tables, or as ascertained, by four times the breadth, and the square of the depth, in inches, and divide the product by the length in feet, the quotient is the result in pounds.

NOTE.—When the beam is loaded uniformly throughout its length, the result must be doubled.

EXAMPLE.—What weight will a cast iron bar, 5 feet between the supports, and 2 inches square, bear in the middle, without permanent injury?

$250 \times 2 \times 4 \times 2^2 = 8000$, *which,* $\div 5 = 1600$ *lbs.*

OR, *If the Dimensions be required to Support a Given Weight.*

RULE.—Divide the product of the weight and length in feet, by four times the *Value* of the material, and the quotient will give the product of the breadth, and the square of the depth of the bar or beam.

When the Weight is not in the Middle between the Supports.

RULE.—Multiply the *Value* of the material in the preceding tables,

or as ascertained, by the length in feet, and the breadth, and the square of the depth, in inches, and divide the product by the product of the distances of the weight, or stress from either support.

EXAMPLE.—What weight will a cast iron bar, 2 inches square and 5 feet in length, support without permanent injury, at a distance of 2 feet from one end, or support?

$$\frac{250 \times 5 \times 2 \times 2^2}{2 \times (5-2)} = \frac{10\,000}{6} = 1666{\cdot}67 \text{ lbs.}$$

To ascertain the Pressure upon the Ends or upon the Supports.

RULE.—1. Divide the product of the weight and its distance from the nearest end or support, by the whole length, and the quotient will give the pressure upon the end or support furthest from the weight.

2. Divide the product of the weight and its distance from the furthest end, or support, by the whole length, and the quotient will give the pressure upon the end or support nearest the weight.

EXAMPLE.—What is the pressure upon the supports in the case of the preceding example?

$$\frac{1666\,67 \times 2}{5} = 666{\cdot}67 \text{ lbs. upon support furthest from the weight.}$$

$$\frac{1666{\cdot}67 \times 3}{5} = 1000 \text{ lbs. upon support nearest to the weight.}$$

When a Bar or Beam, Fixed or Supported at both Ends, bears two Weights at unequal Distances from the Ends.

Let m represent distance of greatest weight from nearest end.
n " distance of least weight "
W " greatest weight.
w " least weight.
L " whole length.
l " distance from least weight to furthest end.
l' " distance of greatest weight from furthest end.

Then, $$\frac{m \times W}{L} + \frac{l \times w}{L} = \text{pressure at } w \text{ end,}$$

and, $$\frac{n \times w}{L} + \frac{l' \times W}{L} = \text{pressure at } W \text{ end.}$$

When a Bar or Beam is Fixed at one or both Ends, or Supported at both Ends, and the Weight increases as the distance from the free end, or from one of the supports, as the case may be.

The effect of the weight is $\frac{6}{3}$ of that which would be produced if it was applied at the end or in the middle; *hence,* for all practical purposes it may be taken as double.

When the Plane of the Bar or Beam projects obliquely Upwards or Downwards.

When Fixed at one End and Loaded at the other.

NOTE.—When the weight is laid uniformly along its length, the result must be doubled.

RULE.—Multiply the *Value* of the material in the preceding tables, or as ascertained, by the breadth and square of the depth, in inches, and divide the product by the product of the length in feet and the cosine of the angle of elevation or depression.

EXAMPLE.—What is the weight an Oak beam, 5 feet in length, 3 inches square, and projecting upwards at an angle of 7° 15′, will bear without permanent injury?

$55 \times 3 \times 3^2 = 1485$, *which*, $\div 5 \times \cos. 7° 15' = 1485 \div \overline{5 \times \cdot 99^2} = 299 \cdot 39$ lbs.

To ascertain the Transverse Strength of Cylinders, Ellipses, &c., &c.

When a Cylinder, Rectangle (the diagonal being vertical), Hollow Cylinder, or Beams having sections of an Ellipse and Equilateral Triangle, are either Fixed at one End and Loaded, the Load applied in the Middle, or between the Supports.

RULE.—Proceed in all cases as if for a rectangular beam, taking for the breadth and depth and *Value* of the material, as follows:—

Cylinder,	diameter^3	$\times \cdot 6$	of *Value.*
Rectangle,*	side^3	$\times \cdot 7$	"
Hollow Cylinder	(diam.^{3} — diam.′^{3}),	$\times \cdot 6$	"
Ellipse, transverse diam.	vertical conj. $\times$ transverse^2,	$\times \cdot 6$	"

Fixed at One or Both Ends.

Equilateral Triangle,	edge up,	breadth $\times$ depth^2,	$\times \cdot 2$	of *Value.*
do,	edge down,	"	$\times \cdot 34$	"
T Bar or Beam,	"	"	$\times \cdot 42$	"

Supported at Both Ends.

Equilateral Triangle,	edge up,	breadth $\times$ depth^2,	$\times \cdot 34$	of *Value.*
do,	edge down,	"	$\times \cdot 2$	"
⊥ Bar or Beam,	edge up,	"	$\times \cdot 42$	"

To ascertain the Diameter of a Solid Cylinder to Support a Given Weight.

When Fixed at One End, and Loaded at the Other.

RULE.—Multiply the weight to be supported, in pounds, by the length of the cylinder, in feet; divide the product by ·6 of the *Value* of the material, and the cube root of the quotient will give the diameter.

NOTE.—When the cylinder is loaded uniformly throughout its length, the cube root of half the quotient will give the diameter.

EXAMPLE.—What should be the diameter of a cast iron cylindrical beam, 8 inches in length, to support 1500 lbs. without permanent injury?

8 inches is ·66 feet. $\frac{15{,}000 \times \cdot 66}{\cdot 6 \times 250} = 66$,

and, $\sqrt[3]{66} = 4 \cdot 04$ inches.

* The strength of a Rectangle, the diagonal being vertical, compared to that of its circumscribing rectangle, when the direction of the strain is parallel to the side of it, is as 245 to 1.

When Fixed at Both Ends, the Weight applied in the Middle.

RULE.—Multiply the weight to be supported, in pounds, by the length of the cylinder in feet; divide the product by ·6 of the *Value* of the material, and the cube root of one-sixth of the quotient will give the diameter.

NOTE.—When the cylinder is loaded uniformly along its length, the cube root of half the quotient will give the diameter.

EXAMPLE.—What should be the diameter of a cast iron cylinder, 2 feet in length between the ends, to support 21,000 lbs. without permanent injury?

$$\frac{21{,}000 \times 2}{\cdot 6 \times 250} = 286, \quad \text{and} \quad \sqrt[3]{\frac{280}{6}} = 3{\cdot}59 \text{ inches.}$$

When Supported at Both Ends, the Weight applied in the Middle.

RULE.—Multiply the weight to be supported, in pounds, by the length of the cylinder between the supports, in feet; divide the product by ·6 of the *Value* of the material, and the cube root of one-fourth of the quotient will give the diameter.

NOTE.—When the cylinder is loaded uniformly along its length, the cube root of half the quotient will give the diameter.

EXAMPLE.—What should be the diameter of a cast iron cylinder, 2 feet between the supports, that will support 60,000 lbs. without permanent injury?

$$\frac{60{,}000 \times 2}{\cdot 6 \times 250} = 800, \quad \text{and} \quad \sqrt[3]{\frac{800}{4}} = 5{\cdot}85 \text{ inches.}$$

And what its diameter, if loaded uniformly along its length?

$$\frac{800 \div 2}{4} = 100, \quad \text{and} \quad \sqrt[3]{100} = 4{\cdot}64 \text{ inches.}$$

To ascertain the Relative Value of Materials to resist a Transverse Strain.

Let V *represent this value in a beam, bar, or cylinder, one foot in length, and one inch square, side, or in diameter;* W, *the weight;* l, *the length;* b, *the breadth;* d, *the depth;* m, *the distance of the weight from one end; and* n, *the distance of it from the other.*

NOTE.—In cylinders, for $b\,d^2$ put d^3.

1. *Fixed at one end.* Weight suspended from the other.

$$\frac{l\ \mathrm{W}}{b\ d^2} = \mathrm{V}.$$

2. *Fixed at both ends.* Weight suspended from the middle.

$$\frac{l\ \mathrm{W}}{6\ b\ d^2} = \mathrm{V}.$$

3. *Supported at both ends.* Weight suspended from the middle.

$$\frac{l\ \mathrm{W}}{4\ b\ d^2} = \mathrm{V}.$$

4. *Supported at both ends.* Weight suspended at any other point than the middle.

$$\frac{m\ n\ \mathrm{w}}{l\ b\ d^2} = \mathrm{v}.$$

5. *Fixed at both ends.* Weight suspended at any other point than the middle.

$$\frac{2\ m\ n\ \mathrm{w}}{3\ l\ b\ d^2} = \mathrm{v}.$$

From which formulæ, the weight that may be borne, or any of the dimensions, may be found by the following:

1. $$\frac{\mathrm{v}\ b\ d^2}{l} = \mathrm{w}\ .\ \frac{\mathrm{v}\ b\ d^2}{\mathrm{w}} = l\ .\ \frac{l\ \mathrm{w}}{\mathrm{v}\ d^2} = b\ .\ \sqrt{\frac{l\ \mathrm{w}}{b\ \mathrm{v}}} = d.$$

In rectangular beams, &c., b and $d = \sqrt[3]{\frac{l\ \mathrm{w}}{\mathrm{v}}}$.

2. $$\frac{6\ b\ d^2\ \mathrm{v}}{l} = \mathrm{w}\ .\ \frac{6\ b\ d^2\ \mathrm{v}}{\mathrm{w}} = l\ .\ \frac{l\ \mathrm{w}}{6\ d^2\ \mathrm{v}} = b\ .\ \sqrt{\frac{l\ \mathrm{w}}{6\ b\ \mathrm{v}}} = d.$$

In rectangular beams, &c., b and $d = \sqrt[3]{\frac{l\ \mathrm{w}}{6\ \mathrm{v}}}$.

3. $$\frac{4\ b\ d^2\ \mathrm{v}}{l} = \mathrm{w}\ .\ \frac{4\ b\ d^2\ \mathrm{v}}{\mathrm{w}} = l\ .\ \frac{l\ \mathrm{w}}{4\ d^2\ \mathrm{v}} = b\ .\ \sqrt{\frac{l\ \mathrm{w}}{4\ b\ \mathrm{v}}} = d.$$

In rectangular beams, &c., b and $d = \sqrt[3]{\frac{l\ \mathrm{w}}{4\ \mathrm{v}}}$.

4. $$\frac{l\ b\ d^2\ \mathrm{v}}{m\ n} = \mathrm{w}\ .\ \frac{m\ n\ \mathrm{w}}{b\ d^2\ \mathrm{v}} = l\ .\ \frac{m\ n\ \mathrm{w}}{l\ d^2\ \mathrm{v}} = b\ .\ \sqrt{\frac{m\ n\ \mathrm{w}}{l\ b\ \mathrm{v}}} = d.$$

In rectangular beams, &c., b and $d = \sqrt[3]{\frac{m\ n\ \mathrm{w}}{l\ \mathrm{v}}}$.

5. $$\frac{3\ l\ b\ d^2\ \mathrm{v}}{2\ m\ n} = \mathrm{w}\ .\ \frac{2\ m\ n\ \mathrm{w}}{3\ b\ d^2\ \mathrm{v}} = l\ .\ \frac{2\ m\ n\ \mathrm{w}}{3\ l\ d^2\ \mathrm{v}} = b\ .\ \sqrt{\frac{2\ m\ n\ \mathrm{w}}{3\ l\ b\ \mathrm{v}}} = d.$$

In rectangular beams, &c., b and $d = \sqrt[3]{\frac{2\ m\ n\ \mathrm{w}}{3\ l\ \mathrm{v}}}$.

When the weight is uniformly distributed, the same formulæ will apply, w representing only half the required or given weight.

When the weight increases as the distance from the free end or from one of the supports, as the case may be, the same formulæ will apply, w representing $\frac{1}{1}\frac{6}{5}$ the required or given weight.

Transverse Strength of Cast Iron.

As Cast iron resists crushing or compression with a greater force than extension, it follows that the flanch of a Girder or Beam which is subjected to a compressing strain, according as the girder or beam

is *supported at both ends* or *fixed at one end*, should be of less area than the other flanch, which is subjected to extension or tensile stress.

The resistance of cast iron to compression and extension, or crushing and tensile strains, is for American, as 4·6 to 1, and for English, as 5·3 to 1.*

The mean tensile strength of American cast iron, as determined by Major Wade for the U. S. Ordnance Department, is 31,829 lbs. per square inch of section; and the mean of English, as determined by E. Hodgkinson, Esq., for the Railway Commission, in 1849, is 16,330 lbs.

The ultimate extension of cast iron is the 500th part of its length.

The mean transverse strength of American cast iron, also determined by Major Wade, is 681 lbs. per square inch, suspended from a bar fixed at one end and loaded at the other; and the mean of English, as determined by Fairbairn, Barlow, and others, is 500 lbs.

The position of the *Neutral Axis* is at the centre of gravity of the section.

From the experiments of Mr. Hodgkinson, it was deduced that with flanched beams I, the area of the bottom flanch should be six times greater than that of the top flanch, and that the two flanches should be connected by a thin vertical arch, sufficiently rigid, however, to possess lateral strength.

The most effective outline of a cross section of the web is one tapering outwards, both upwards and downwards from the neutral axis, and meeting each flanch with a thickness corresponding to that of the flanch.

Transverse Strength of Wrought Iron.

As Wrought iron resists crushing or compression with a greater force than extension, it follows that the flanch of a Girder or Beam, which is subjected to a crushing strain, according as the girder or beam is *supported at both ends*, or *fixed at one end*, should be of less area than the other flanch, which is subjected to extension or a tensile strain.

The resistance of wrought iron to compression or extension, or crushing and tensile strains, is for American as 1·5 to 1, and for English, as 1·2 to 1.

The mean tensile strength of American wrought iron, as determined by Professor Johnson, in 18—, is 55,900 lbs., and the mean of English, as determined by Capt. Brown, Barlow, Brunel, and Fairbairn, is 53,900 lbs.†

The ultimate extension of wrought iron is the 600th part of its length.

The resistance to flexure acting evenly over the surface, is nearly one-half the tensile resistance.

The position of the *Neutral Axis*, alike to that of cast iron, is at the centre of gravity of the section.

*The experiments of Mr. Hodgkinson on iron of low tensile strength, gives a mean of 6·595 to 1.

†The results, as given by Telford, included experiments upon Swedish iron, hence they are omitted in this summary.

(To be Continued.)

The Caloric Engine.

[Proceedings of the Polytechnic Association of the American Institute, Oct. 31, 1860, from the Architects and Mechanics' Journal. Corrected by T. D. STETSON, Esq.]

The President proposed three questions to be answered by those explaining the caloric engine: first, as to the burning out of the heaters; for if they are liable to be burned out frequently, it is an objection to its economical use, not only from the expense, but from the frequent interruptions in the working of the engine. The second, also in the form of an objection, relates to the small amount of force that could be accumulated. The air being heated as it is used, no provision can be made, as in the steam boiler, for a supply of work for a little time. The heating-up occurs at the moment, and is liable to disappointment upon the slightest accident or occasion of delay. The third and strongest objection relates to the small amount of power that is obtained. It is only changing one gas, not into another, but an expansion of the same gas; whereas in making steam, we expand a liquid instantly to 1700 times its bulk. In air engines, double the volume is all that is usually obtained. He would like to hear either some answer to these objections, or evidence that, in spite of these objections, the economy is such as to make the caloric engine valuable.

Mr. G. H. Babcock exhibited drawings of Wilcox's caloric engine, (an engine recently invented by S. Wilcox, Jr., of Westerly, R. I.,) and explained its construction and mode of operation. Although air engineering is younger than steam engineering, much attention has been paid to it, between 200 and 300 patents having been granted for air engines, or improvements upon air engines, in Great Britain alone, and thirty-five in the United States. These may all be classified in four grand divisions. In the first class may be placed all those engines in which a reservoir of expanded air is maintained as a reservoir of power, similar in effect to the steam boiler. The air is allowed to escape into an engine of proper character, and worked off like steam from a steam boiler. The second class includes all those which use the gaseous products of combustion within the engine. The power may be generated within the engine itself, or in a heater; this class will include the explosive engines. The third class includes the engines which use a certain quantity of air, which is alternately heated and cooled in opposite portions of the stroke; the difference in temperature in different parts of the stroke generating power in the engine. The Stirling engine belonged to this class. The fourth class includes all those engines which use atmospheric air, drawing their supply from the atmosphere at each stroke, and exhausting again into the atmosphere. This class will include the great experimental caloric ship of Ericsson, the small caloric engine of Ericsson, and also the Wilcox engine; it includes all the caloric engines now in successful use.

The President.—Please to state why these are the only ones in use.

Mr. Babcock.—I do not know that there is any good reason why there are not engines of the third class. The second class, in which

the gaseous products of combustion are used, have, in all cases so far, failed because of the excessive heat occasioned by combustion, and of the abrasion occasioned in the cylinder and other working parts by the solid products of combustion. And for the first class I know no positive reason.

The President.—Are there not difficulties connected with accumulating a reserve of power?

Mr. Babcock.—There are practical difficulties in condensing the air. Some power is lost in the condensation, owing to the development of heat in the compression, which is lost, in a great measure. Of all the experiments which have been made, there seem to have been but three which have been practically successful: the Stirling engine, the Ericsson engine, and the Wilcox engine. The Stirling engine, after the death of the inventor, having been disused, in consequence of the jealousy of steam engineers, the Ericsson and Wilcox engines are the only ones now in practical operation. Of the Ericsson engine, several hundreds have been constructed, and are now in operation.

The President.—How small a power is used?

Mr. Babcock.—One-man power, which is about a fifth of a horse power, is considered quite a respectable power. To drive an ordinary sewing machine requires about one-sixtieth of a horse power. One of the small air engines would drive quite a number of these machines. The Ericsson engines run up to two horse power in some cases; perhaps more for the double engines. The Wilcox engine has not been fully tested. There is an 18-in. Wilcox engine estimated by the owners as 3½ horse power, in a large bakery in Pawtucket. This is probably above its actual power. It is stated that it does not average over 60 lbs. of coal in 12 hours, and has run with 46 lbs.

The Wilcox engine has two upright cylinders connected at their lower ends next to the fire. One of the cylinders is used as a working cylinder and is single-acting, open at the upper end. The other, termed a changing cylinder, is double-acting, but the piston is always in equilibrium, so that all the resistance it occasions is due to the friction of the air and the friction of the parts. The pistons are connected with cranks upon the main shaft, which are placed nearly at right angles. This produces a motion nearly corresponding to the theory, which would be that each piston should make its entire stroke while the other is at its dead-point. Between these two cylinders is the economizer, a chamber so filled with thin metal plates as to allow the free passage of air, and connected with both cylinders at the bottom. It is intended to absorb as much as possible of the heat of the air passed upwards through it, and to return it to the next downward current. It has been contended that the economizer is of no theoretic value. Practice seems to prove its value in this engine at least, for the engine has been found to run light, other circumstances being equal, twice the number of revolutions with the economizer that it will run without it. It is also found that the engine will keep running for half an hour or more, by simply passing the same air back and forth; the valve being so set as not to take in any fresh air. Above the econo-

mizer is the valve chest, which contains a single rolling three-way valve, with the three-fold office of induction, eduction, and equilibrium valve. The heat is applied at the bottom, not by direct radiation, but by passing the products of combustion under and around the cylinders. In consequence of cutting off the direct radiation, the heaters are expected to last longer. The heaters are prevented from being overheated by automatic action; the vapor of mercury, which is formed at 600°, operating means which shut off the heat from the cylinders.

The President inquired what was the durability of the heaters.

Mr. Babcock stated that the engines had only been in operation for six months, so that there were no means of knowing. The Stirling engine heaters lasted for two years, and these ought to last as long.

A gentleman inquired how it was lubricated.

Mr. Babcock explained how the oil was prevented from being burned. A perforated cover was placed on the open end of the working cylinder, the perforations being slightly inclined, so that at each descent of the piston, the cool air impinged upon the metal in numerous streams, to be driven out again on its ascent, thus conveying away the heat. He stated that there was no packing in the piston in the inclosed cylinder, there being always nearly an equilibrium in that cylinder.

Mr. Churchill inquired what were the cubical contents of the economizer.

Mr. Babcock stated that it was about one-fourth the size of one of the cylinders.

A gentleman inquired what was the economy of this engine.

Mr. Babcock said that if the Pawtucket engine had a two horse power, it burned 2½ lbs. of coal per hour to the horse power; which was about one-third of what any steam engine of the same power would require. *Large* steam engines sometimes run with as little coal in proportion to their power.

Mr. Babcock explained, by the aid of several large and finely executed diagrams, the motions of the several parts, and the pressure under the working piston at each point in the revolution, which attracted much attention. He explained that the pressure was derived from theory, and would be somewhat less in practice; but would not probably vary more than 25 or 30 per cent. from that indicated upon the diagrams. The maximum pressure by the diagrams was 22 pounds above the atmosphere; the pressure being about two-thirds that amount at the commencement, increasing to near one-quarter stroke, and thence declining till the exhaust valve opens.

The President.—Inasmuch as all that you do to the air is to double its volume, while in raising steam you increase the volume 1700 times, wherein does the economy lie?

Mr. Babcock.—In the greater facility of heating air, and its small amount of specific heat, which is only one-fourth of that of water. There is also much heat lost in raising water to the boiling point.

The President.—Is this engine free from danger?

Mr. Babcock.—Perfectly free from all danger.

Mr. C. A. Seely expressed his surprise that the peculiar circumstance of the difference of the specific heat of air and water had not

been mentioned before. The same heat will heat a pound of air four times as high as a pound of water.

Mr. F. Dibben said the Wilcox engine was very similar to the Ericsson engine, but in comparing the two, and estimating the contents of the working cylinder, it would be necessary to take the contents of both cylinders in the Wilcox engine, since the two correspond to the one in Ericsson's. He failed to appreciate the difference between Mr. Wilcox's engine and the engines in the caloric ship *Ericsson*, in 1853.

Mr. T. D. Stetson explained one of the great points in which the Wilcox engine differed radically from those in the *Ericsson*. In that ship, the supply of air was forced in by pumping it through large force pumps, against the pressure which obtained within. In the Wilcox engine, there is a period while the working piston is descending, where the whole interior of the engine is in free communication with the external atmosphere. During that period, the changing piston descends and inhales a full charge of cold air above it, precisely as the air enters an accordeon when it is expanded. The descent of the changing piston occasions no resistance, because there is then no pressure against the under side of that piston. The moment it is thus inhaled, the induction port closes, and the dense cold air is subsequently transferred by the rising of the changing piston into the hot part of the engine, when, by its expansion, the working piston is forced up, and power is developed. The rising of the changing piston occasions no resistance, because while it rises the same pressure obtains on its under as on its upper side, whatever that may be. The two sides are in free communication through the openings in the economizer. As the changing piston rises and compels the air above it to pass down through the economizer into the hot part of the engine, the pressure rises in consequence of the heat received by the air; but it is felt equally on the upper and under side of the changing piston, and is only sensible on the working piston, which latter receives the pressure on its under side. The upper end of the working cylinder it always opens to the atmosphere. The question of most interest, Mr. Stetson believed, was not the difference between this and the previous varieties of air engines, but whether either or any had practically solved the problem presented, and was really a successful and important machine. He believed that both Ericsson's and Wilcox's engines were fairly entitled to be thus considered. Between five and six hundred of the Ericsson engines, and a small number—about a dozen—of the Wilcox engines are now in daily and successful use.

Mr. Roosevelt inquired if the caloric yacht was not lying up. Was she a success? He had seen a boat driven by a "six horse power" caloric engine, which could be driven as well by two men with oars. He could stop any caloric engine by pressure upon the periphery of the fly wheel with an axe.

Mr. Stetson said the engine was, to his certain knowledge, doing efficiently and satisfactorily the work for which it was purchased, in a great number of instances, without involving any expense for attendance, or increasing the rate of insurance. He confessed that Ericsson's engines are very much over-rated in their power. He had tested

one carefully by the friction-brake. It was an 18-inch engine, employed in driving printing-presses at Dodge & Grattan's, in this city. It was rated by some at four-horse power. Mr. Stetson found that, when diligently fired, it performed with exactly two-thirds of one horse power. But the extravagance of some estimates should not lead us to under-rate its actual performance. The caloric engine, both of Ericsson and Wilcox, was a success. It was difficult to compare strictly with steam engines. The performance of an engine depends upon many conditions; so that a steam engine of "two-horse power" may do the work of only one man, or of six or eight horses. The expense and trouble of replacing the heaters is very small. The Ericsson heaters are much more exposed than the Wilcox heaters; but even in the Ericsson engine the most exposed parts endured a year or more with moderately hard firing, and were replaced at an expense of only $15. The great economy of the caloric engine, mainly arose from the ease with which it may be kept in operation without a professional engineer.

Mr. J. K. Fisher remarked that some steam engines were worked at less than atmospheric pressure; so that the safety of those steam engines is as great as that of the caloric engines.

Lieut. Bartlett thought there should be no contest between steam and air engines. The steam engine has proved itself to the world. But there is a great want of an economical very small power, which requires little skill or attention. He had not hesitated to say to Mr. Ericsson that his success and his fame would rest upon the fact that he had supplied a little power, which was a very great necessity in the community.

For the Journal of the Franklin Institute.

Steamboat Speed.

The steamboat *Daniel Drew*, the details of which I furnished for your July number, page 47, has lately made a run from New York to Albany, 150 miles, in the unprecedented time of 6 hours and 50 minutes, tide favorable, but wind ahead: her time to Hudson, 125 miles, was 5 hours and 5 minutes, which is equal to a speed of 24·6 miles per hour. From this is to be deducted the velocity of the tide, a full allowance for which is 2·3 miles, leaving 22·3 miles per hour as the actual speed of this boat through the water, with an adverse wind.

The time to Hudson is selected from the circumstance, that above that point, the river is too shallow to admit of very high speeds.

The times of previous quick runs are as follows:—

North America,	1826,	10	hours,	20	minutes.
do. lengthened,	1832,	9	"	21	"
Albany,	1840,	8	"	27	"
Troy,	1841,	8	"	10	"
Alida,	1849,	7	"	45	"
New World,	1851,	7	"	43	"
Francis Skiddy,	1852,	7	"	30	"
Armenia,	1860,	7	"	42	"

C. H. H.

Description of Carlsund's Drain Valve, with a suggested Improvement on the same. By JOHN W. NYSTROM.

A great deal of difficulty is frequently experienced by water coming into the cylinder in steam engines. The principal cause of this inconvenience arises from priming in the steam boilers, by which the water comes into a violent motion, and fills the steam room in the form of foam, which finally is carried along with the steam into the cylinders, and when in too great a quantity, it partly resumes the water form in the cylinder, and does not go out with the exhaust steam until the piston approaches the end of the return stroke, when the slide valve has closed the eduction passage; the inclosed water then causes a violent blow between the piston and the cylinder head, which infallibly produces an undue strain in the machinery. Sometimes this inconvenience does not end in straining or breaking the crank pin, but the incompressibility of the water against the momentum of the machinery assists directly in demolishing the whole engine.

To overcome this difficulty, arrangements must be made to drain the cylinder, for which purpose cocks are most frequently used in high pressure engines, to be opened by hand when notice is given by the water inside.

This notice is first given gently by noise in the cylinder, but according to the rate of priming, within a few strokes the shocks may become so strong as to break the cylinder bottoms, if the engineer is not attentive in opening the cocks. Condensing engines are frequently supplied with safety valves on the cylinder, loaded a little more than the steam pressure; these valves are called "escape valves," and generally loaded with a spring, so that when the space between the piston and the cylinder head is full of water, the piston forces it out through the escape valve. This is found to work very well, and it is self-operating, but in particular cases, to be described hereafter, the arrangement adopted by Captain Carlsund is by far preferable, as it drains the cylinder completely at every stroke, without an undue strain in the machinery.

In some cases the escape valves do not fully answer the purpose; for instance, in the upright trunk propeller engines, adopted lately in the Russian Navy, the water enters from the condenser and half fills the cylinders, the escape valves will not operate, and it is very difficult to start the engines.

Fig. 1 represents a horizontal steam cylinder, with its piston P moving in the direction of the arrow—at the end of the stroke the water will occupy part of the clearance between the piston and the cylinder head, until the steam enters and forces the water out through the valve *a* and the pipe *b* into the reservoir *c*, which latter contains a float *d* fixed on a tube *e e*, movable up and down, and guided in boxes as shown by the drawing. The tube *e e* has a number of holes in its lower end, covered by the box; when there is water enough in the reservoir *c* to lift the float *d*, with the tube *e e*, the small holes will enter the reservoir, through which the water is forced out by the steam, and thus the

cylinder is drained at every stroke of the piston. The reservoir *c* is always full with water and steam, with nearly the same pressure as that in the cylinder; no steam is lost except what is condensed in the reservoir and pipes, by radiation of heat. The tube *e e* is ground into the boxes so as to be steam-tight, but can still move freely up and down, as regulated by the water displacement of the float. By this arrangement, no water can be collected in the cylinder, except what is formed during one stroke of the piston, and no shocks or breaking of machinery need be feared.

Fig. 1.

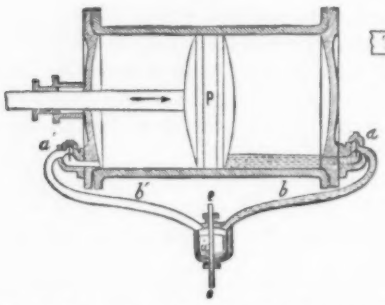
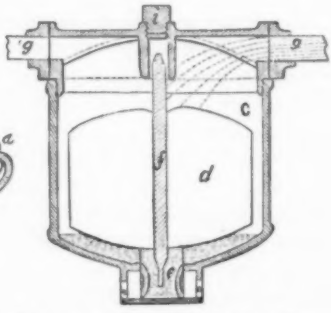


Fig. 2.



The tube *e e*, guided in the boxes, forms an equilibrium valve,—if the float *d* was connected with a common valve at the lower end, the steam pressure would be too great for the displacement to lift it up, therefore, some kind of equilibrium valve is necessary. Captain Carlsund has named the valve boxes *a a*, "Separatuers," and the reservoir *c*, "Floatuer." This arrangement of drain valves seems to be of great importance in marine engines, particularly when the steam boilers are subject to priming. However good the principle of an invention or arrangement may be, a slight defect in the details will most frequently damage the whole;—in this case, I beg to remark that the efficiency of the operation depends on the quality of the workmanship in grinding the tube *e e* in the boxes. If it is ground too loose, steam will leak out; if too tight, it will not operate well, and a slight difference in the expansion of the tube and boxes may cause its operation to be deficient. This consideration has led me to suggest an improvement on Captain Carlsund's drain valves,—the separators *a a*, the pipes *b b*, and the principle of operation remaining the same as described, only the floatuer *c*, I would suggest to make as represented by Fig. 2.

The improvement consists principally in the equilibrium valve *e*, Fig. 2, resting on the bottom of the box *h*. The valve *e* is connected to the float *d* by four wings cast in one piece with the spindle *f*. The operation of the valve is readily understood by the drawing, the steam and water entering the reservoir *c*, alternately through the pipes *g g*. When the float *d* lifts the valve *e*, the water is forced out by the steam through the holes *o o*, the valve is guided by the four wings, also by the spindle *f*, at the top. The screw *i* is taken out when the valve is

to be ground in, for which purpose the top of the spindle is made square. The lower part of the valve *e*, to be turned into a sharp edge of the same diameter as the upper part, which will make the valve perfectly equilibrium, and the steam pressure has no effect to open or close the same, but is under the sole control of the displacement of the float *d*. When there is no water in the reservoir, the weight of the float will keep the valve tight, but it need not be so perfectly tight, because there will always be some water which at any rate is to be let out.

The floatuer *c* need not be placed under the cylinder as represented by Fig. 1; it can be placed on the side, or any where in the engine room.

A "drain valve" constructed on this plan will fully answer the desired purpose; it will drain the cylinder at every stroke of the piston, and there is no danger of any thing getting out of order.

It is of great importance to have this drain valve introduced in the corvette, where the steam boilers are so much subject to priming. A great deal of inconvenience has been experienced in the corvette by water coming into the cylinders.

The drain valve can also be applied to vertical cylinders.

It will be perceived, that when water primes into the cylinder in the down stroke, it must remain on the top of the flat piston until it returns and approaches the cylinder head, where it will strike with more or less violence, according to the quantity of water therein, the other engine being then on about half stroke, and has the greatest power to force the water out through the escape valve, which being loaded with, say 25 lbs. per square inch, will be a resistance on the piston of about 52 tons; but the incompressibility of the water striking suddenly between the two flat surfaces will exert a much greater force, and cause an undue strain in the machinery. The water which may prime into the cylinder under the piston will mostly be carried out with the exhaust steam, unless the quantity be very large, then the case will be the same as at the top.

In all those upright trunk engines there is another circumstance which admits water coming into the cylinders, namely, the eduction passage being placed in such position that water may pass from the condenser. It has therefore been proposed to put a copper plate into the condenser to prevent the water from entering the cylinder. The condenser is about 7 feet square inside, and the eduction passage is near to the starboard side; in a hard sea, and the ship leaning to the starboard, the water rolling in the condenser, it will be difficult to keep it out of the cylinder without the plate. It has been found in the *Wiborg* engines that the escape valves are not sufficient for draining the cylinders, for, when starting the engines, the cylinder may be half full of water, the steam pressure will not be sufficient to force the water out through the escape valves; therefore, it has been found necessary to place drain pipes from the bottom of the cylinders connected with stop cocks, to be operated by hand, but even by this, the cylinders cannot be well drained, because the drain pipes must be led upwards to where there is a place for the cock.

On the *Rattvisan* it is intended to put stop cocks, by which the cylinders can be drained only partially, and a body of water will still remain on the bottom for the piston to plunge into.

It has been proposed to the Technical Committee to apply the drain valves herein described to the upright trunk propeller engines, and the cylinders would be perfectly drained at every stroke, self-operating, and no dependence required on the engineer for the same. The drain valve would not operate so well on top, because the piston is so flat, but in all cases it would do better than the escape valve or stop cock, if properly arranged.—*Artizan, Oct.*, 1860.

Tensile Strength of Iron increased by Rolling.

There are some inventions which address themselves to our notice with much elaborate comparison of results between old and new methods of effecting the same object, and there are others which, from their very completeness and self-containedness (to coin a word), admit of scarcely more than the simple announcement of the fact of their discovery. The invention of James Watt's separate condenser might have been given to the world in half a dozen lines, whilst as many pages are usually dedicated to the introduction of a new brickmaking machine. We feel it necessary to premise thus much, because we wish to draw the attention of our readers to a fact which will be new to all of them (with the exception of a very limited circle), and which places us under the disadvantage above alluded to, of giving us no chance of making a long article about it. The fact, then, is simply this:—

Given, a bar of common malleable iron: it is possible, by a purely mechanical process, and without the aid of heat, to increase the tensile strength of that bar 50 per cent. "On what principle?" it will be asked. On the same principle that wire is stronger per square inch of section than the bar from which it was originally drawn. To Mr. Lauth, an American engineer, is due the merit of making this particular egg stand on end, and his process is, as will be seen, of the simplest. Bars of common merchant iron are passed cold between grooved rollers, until the requisite degree of compression is attained. We saw, at the works in Manchester, a bar, $2\frac{1}{8}$ ins. diameter, and 15 ft. long, rolled down to 2 ins. in ten minutes—(with practice, this time could be reduced one-half). This $\frac{1}{8}$-in. is not lost—as in turning a shaft in a lathe—as the bar is lengthened about $1\frac{1}{2}$ ins. to the foot. The bar came out quite polished, and parallel enough for shafting, but not quite straight. It was straightened by hand by two men in half an hour, and might be done by machinery in a few minutes. According to Mr. Fairbairn, "the effect of the consolidation was to increase the strength of the bar in the ratio of 10 to 15," in the experiments made by him. We think we have said enough to give all our readers a motive for wishing to hear of this invention being made accessible to the public.—*London Engineer, No.* 247.

For the Journal of the Franklin Institute.

Particulars of the Steamer Pembroke.

Hull and machinery by Atlantic Works, Boston, Mass. Owners, Wm. E. Coffin & Co. Intended service, from Boston to Pembroke.

Hull.—Length on deck, 110 ft. Do. at load line, 107 ft. Breadth of beam (molded), 24 ft. 6 ins. Depth of hold, 9 ft. Do. to spar deck, 9 ft. Frames—apart at centres, 24 and 30 ins.; ⅂, depth, 3·5 ins.; width of web, ⅜ in.; width of flanches, 2·5 ins 10 strakes of plates from keel to gunwale; thickness of plates, ¼ to ⅜ in. Cross Floors, ⅜, ½ by 12 ins., single riveted. One independent steam, fire, and bilge pump. Two bulkheads. Length of engine room, 30·3 × 7·5 ft. Draft, aft, 9 ft. 3 ins. Tonnage, hull and engine room 215. Area of immersed section at load draft of 9 ft. 3 ins., 146 sq. feet. Masts, two.—Rig, schooner.

Engine.—Vertical beam. Diameter of cylinder, 26 inches. Length of stroke, 3 feet. Maximum pressure of steam, 30 lbs. Cut-off, variable. Maximum revolutions at above pressure, 60. Weight of engines, 31,078 lbs.

Boiler.—One—Tubular return. Length of boiler, 14 ft. Breadth do., 6 ft. 6 ins. Weight do., without water, 19,593 lbs. Number of furnaces, two. Length of grate bars, 5 ft. 6 ins. Number of tubes, above, 72; flues, below, 2. Internal diameter of tubes, above, 4 ins.; flues, below, 1 ft. 8 ins. Length of tubes, above, 9 ft. 2 ins.; flues, below, 5 ft. 8 ins. Heating surface, 1329 sq. ft. Diameter of smoke pipe, 2 ft. 8 ins. Height do., 32 feet.

Propellers.—Diameter of screw, 8 feet. Length do., 2 ft. 6 ins. Pitch do., 17 to 20 ft. Number of blades, three.

Date of trial, October, 1860. C. H. H.

For the Journal of the Franklin Institute.

Particulars of the Steamer General Flores.

Hull built by Kirkman & Co. Machinery by Pusey, Jones & Co., Wilmington, Del. Intended service, Coast of Callao.

Hull.—Length on deck, from fore part of stem to after part of stern post, above the spar deck, 109 feet. Do. at load line, 102 feet. Breadth of beam at midship section, 19 ft. 6 ins. Depth of hold to spar deck, 8 ft. 6 ins. Floor timber at throats—molded, 10 ins., sided, 6 ins.—apart at centres, 22 inches. Length of engine and boiler space, 10 ft. 5 ins. Draft of water at load line, 8 ft 6 ins. Do., below pressure and revolutions, 7 ft. 6 ins Tonnage, custom house, 170. Area of immersed section at load line of 8 ft. 5 ins., 135 sq. ft. Displacement at load line, 295 tons. Masts and rig, fore-topsail schooner.

Engine.—Vertical condensing. Diameter of cylinder, 24 inches. Length of stroke, 2 ft. 4 ins. Maximum pressure of steam, 25 lbs. Cut-off, 6 to 18 ins. Maximum revolutions per minute, 75. Weight of engine, 30,300 lbs.

Boiler.—One—Horizontal tubular Length of boiler, 19 ft 2 ins. Breadth do., 6 ft. Height do., exclusive of steam chimney, 5 ft. Number of furnace, one. Breadth do., 4 ft. 11½ ins. Length of grate bars, 4 ft 6 ins. Number of tubes, 57 of 3·5 ins.; 8 of 3 ins. Length do., 9 ft. Heating surface (fire and flues), 696 sq. ft. Grate sur-

face, 22·5 sq. ft. Diameter of smoke pipe, 2 ft. 4 ins. Height do., 20 ft. Draft, natural. Consumption of coal per hour, 290 lbs.

PROPELLERS.—Diameter of screw, 7 ft. 6 ins. Pitch do., 14 feet. Number of blades, four.

Remarks.—Poop cabin. C. H. H.

For the Journal of the Franklin Institute.

Particulars of the Steam Towboats Resolute and Reliance.

Hull built by B. C. Terry, N. J. Machinery by Cobb & Fields, Jersey City, N. J. Owner, Capt. Albert DeGroot. Intended service, New York Harbor.

HULL.—Length on deck, 93 ft. Do. at load line, 93 ft. Breadth of beam, 16 ft. Depth of hold, to spar deck, 7 ft. 6 ins. Frames—molded, 8 ins., sided, 5 ins —apart at centres, 12 ins. Keel, 12 ins. Draft, forward, 5 feet, aft. 8 feet. Tonnage, 100. Area of immersed section at load draft of 8 feet, 65 sq. feet. Speed in miles in 61 minutes, with tide, 17·5, against tide, 12·5.

ENGINES.—Vertical direct. Diameter of cylinder, 17 ins. Length of stroke, 17 ins. Maximum pressure of steam, 100 lbs.; average pressure, 75 lbs. Cut-off, ½ stroke. Average revolutions at above pressure, 95. Weight of engines, 20,160 lbs.

BOILER.—One—Return tubular. Length of boiler, 15 feet. Breadth do., 6 ft. 8 ins. Height do., exclusive of steam chimney, 8 feet. Weight do., without water, 18,000 lbs., with water, 29,180 lbs. Number of furnaces, two. Breadth do., 3 ft. 4 ins. Length of grate bars, 6 ft. 8 ins. Number of tubes, above, 58, flues below, 6. Internal diameter of tubes, above, 4 ins.; flues, below, 2 of 10 ins., 4 of 6 ins. Length of tubes, above, 10 ft. 4 ins; flues, below, 6 ft. 10 ins. Grate surface, 48 sq. ft. Heating surface, 2500 sq. ft. Diameter of smoke pipe, 3 ft. 2 ins. Height do., 12 ft. Consumption of coal per hour, ¼ ton.

PROPELLER.—Diameter of screw, 7 feet 8 inches. Length do., 5 ft. 6 ins. Pitch do., 14 ft. Number of blades, four.

Date of trial, September, 1860. C. H. H.

For the Journal of the Franklin Institute.

Particulars of the Steam Towboat A. T. Morris.

Machinery by Cobb & Fields, Jersey City, N. J. Intended service, New York Harbor.

HULL.—Length on deck, 93 ft. 6 ins. Do. at load line, 93 ft. Breadth of beam, 16 ft. Depth of hold to spar deck, 7 ft. 6 ins. Frames—molded, 8 ins., sided, 5 ins.—apart from centres, 12 ins. Keel, depth, 12 ins. One independent steam, fire, and bilge pump. Draft, forward, 5 ft., aft, 8 ft. Tonnage, 101. Area of immersed section at load draft of 8 ft., 65 sq. ft.

ENGINES.—Oscillating. Diameter of cylinders, 17 inches. Length of stroke, 17 ins. Maximum pressure of steam, 100 lbs.; average of steam, 75 lbs. Cut-off, ½ stroke. Maximum revolutions at above pressure, 95. Weight of engines, 19,500 lbs.

BOILER.—One—Return tubular. Length of boiler, 15 ft. Breadth do., 6 ft. 8 ins. Height do., exclusive of steam chimney, 8 ft. Weight do., without water, 18,000 lbs., with water, 29,000 lbs. Number of furnaces, two. Breadth do., 3 ft. 4 ins. Length

of grate bars, 6 ft 8 ins. Number of tubes, above, 58; flues, below, 6. Internal diameter of tubes, above, 4 ins.; flues, below, 2 of 10 ins., 4 of 6 ins. Length of tubes, above, 10 ft. 4 ins.; flues, below, 6 ft. 10 ins. Grate surface, 48 sq ft. Heating surface, 2500 sq. ft. Diameter of smoke pipe, 3 ft. 2 ins. Height do., 12 ft. Consumption of fuel per hour, ¼ ton.

PROPELLERS.—Diameter of screw, 7 ft. 8 ins. Length do., 5 ft. 6 ins. Pitch of do., 14 ft. Number of blades, four.

Date of trial, October, 1860. C. H. H.

AMERICAN PATENTS.

AMERICAN PATENTS ISSUED FROM OCTOBER 1, TO OCTOBER 31, 1860.

Adding Machines,	T. T Strode,	Mortonville,	Penna.	2
Air Engines,	John Ericsson,	City of	N. Y.	9
Alarm for Doors,	Henry Behn,	"	"	2
Bag Machines,—Paper	H. G. Armstrong,	Philadelphia,	Penna.	2
Ballot Boxes,—Detect. Fraud in	M. J. Shinn,	Richmond,	Ind.	23
Bank Notes, &c.,—Engraving	James Macdonough,	City of	N. Y.	23
Barrel-head Machine,	H. L. McNish,	Lowell,	Mass.	9
Barrels	Sheridan Roberts,	Cleveland,	Ohio,	16
Bed Bottom,	Wm H Tambling,	Berlin,	Wis.	16
———	Philip Ulmer,	Charlestown,	Mass.	2
Bedstead Fastening,	Aaron Bechtol,	Berkley Spr'gs,	Va.	9
———,—Folding	A. M. Dye,	Clinton,	Ill.	9
———,—Fan Ventilating	F. Moore,	Panola,	Miss.	23
Beehives,	S. R. Bryant,	Waterford,	Penna.	2
———	Palmer & Leeny,	Port Republic,	Va.	9
———	H. M. Shaffer,	Bucyrus,	Ohio,	2
Bell Attachment,	A E Taylor,	Ogdensburgh,	N. Y.	23
Bells,—Hanging	G. R. Meneely,	West Troy,	"	9
Biers,	Wm Scarlett,	Aurora,	Ill.	2
Bill of Fare,—Frame for	C. Gloyd,	Wynant,	Ohio,	9
Binding Engravings, &c.,	W. T. Anderson,	Brooklyn,	N. Y.	2
Bit Stock,	Wallace Lyon,	Deep River,	Conn.	23
Blind Hinges,	E. R. Shepard,	Scranton,	Penna.	2
Blind Slat Machine,	H. B. Smith,	Lowell,	Mass.	16
Boot and Shoe Heels,—Cutting	E T Green,	Stoneham,	"	9
———————,—Dressing	Stuart & Corson,	Marblehead,	"	23
——— Soles,—Cutting	C. H. Griffin,	Lynn,	"	23
—— Crimping Machine,	Philander Shaw,	Abington,	"	23
Boots and Shoes,	S. F. Dexter,	Paris,	N. Y.	16
———	Port & Surgi,	New Orleans,	La.	16
———,—Heel for	W. H. Peckham,	Hoboken,	N. J.	30
———,—Gaiter	C. K. Bradford,	Lynn,	Mass.	2
———,—Tools for Trimming	L. C. Rogers,	Danvers,	"	16
Bracelets,—Manufacture of	George Sanford,	Providence,	R. I.	2
Brackets,—Roof	Amos Jones,	Lebanon,	N. H.	9
Brick Machines,	John Parsons,	Cleveland,	Ohio,	30
—— Moulding Machines,	Hutchison & Brandberry,	C. Gerardeau,	Mo.	16
Bridle Bits —Attachment for	J. D. Tracy,	Springfield,	Mass.	23
Brush Machine,	John Ruegg,	St. Louis,	Mo.	9
Bucket,—Collapsible	C. W. Curtis,	New Haven,	Conn.	23
Calculi,—Removing	Wm. A. Dudley,	Petersburg,	Va.	23
Canal Locks, &c.,—Gates of	Hurlburt & Thompson,	Port Byron,	N. Y.	9

Cane Juice,—Evaporating	Richard Wright,	London,	Engl'd.	16
Canes, &c.,—Handles for	Harvey & Ford,	Philadelphia,	Penna.	2
Cannon Balls —Cast. Packing on	Lewis Evans,	Morgantown,	Va.	30
Cans, Seaming	H. Y. Wildey,	Philadelphia,	Penna.	16
Carriage Jack,	J. J. Pike,	Chelsea,	Mass.	9
Cars,—Light for	Robert Cathcart,	Baltimore,	Md.	9
Chimney Tops,	John Pettingell,	Lowell,	Mass.	9
Chloride of Lead,—Manufac. of	F. F. Myer,	City of	N. Y.	23
Churn,	J. W. Kellberg,	Pittsburgh,	Penna.	16
———	W. W. Reid,	Rochester,	N. Y.	16
——— Dashers,—Blades of	S. T. Lamb,	N. Washington,	Ind.	16
———	J. J. Watson,	Buffalo,	N. Y.	16
Clothes Dryer,	Elliot Dickerman,	Richmond,	Vt.	30
——— ———	Charles Robinson,	Cambridgeport,	Mass	2
——— ———	Josee Johnson,	City of	N. Y.	30
——— Squeezers,	Francis Arnold,	Middle Haddam,	Conn.	23
Combs,—Glass	G. W. Scollay,	St. Louis,	Mo.	2
——— —Wooden	Frederick Brubach,	Lancaster,	Penna.	9
Copying Letters,	A. L. Adams,	Philadelphia,	"	9
Corn Husks.—Stemming	D. M. Mefford,	Jeffersonville,	Ind.	2
—— Planters,	J. W. Harbin,	Delaware Sta.	"	16
—— Shellers,	G. W. Hathaway,	Tioga,	Penna.	16
Cotton Cleaners,	Wm. H. Johnson,	Richmond,	Ark.	2
——— ———	J. W. Thorne,	Courtland,	Ala	16
Couplings,—Car	Adam Ott,	Minetto,	N. Y.	23
——— ———,—Hose	C. F. Spencer,	Rochester,	"	2
——— ———,—Socket	E. P. Gleason,	Providence,	R. I.	16
Cows,—Stabling	Patrick Burke,	Helena,	N. Y.	9
Crane,—Portable,	Snyder & Smith,	Hawley,	Penna.	9
Culinary Apparatus,	Israel Forman,	Grafton,	Va.	2
Cultivators,	N. C. Carter,	Union City,	Ind.	9
——— ———	Cyrus Debolt,	Ottawa,	Ill.	9
——— ———	Wm. May,	Winchester,	Ohio,	16
Curtain,—Window	Butterfield & Bowker,	Boston,	Mass.	16
——— Fixture,—Window	N. H. McLean,	U. S. A.		2
Diaper Pins,	H. S. Lesher,	Brooklyn,	N. Y.	2
Door Spring,	Boyd & Belford,	Philadelphia,	Penna.	16
——— ———	R. B. Donaldson,	Washington,	D. C.	30
Dovetailing Machines,	Bain & Brown,	Richmond,	Ind.	16
Drying Chambers,	J. E. Tourné	New Orleans,	La.	16
Egg-beater,	Uriah Baker,	Brooklyn,	N. Y.	23
Electro-magnetic Helix,	Maurice Vergnes,	City of	"	2
Emery Wheels,	J. D. Alvord,	Bridgeport,	Conn.	2
Engines,—Caloric	A. A. Henderson,	Portsmouth,	N. H.	9
———,—Electro-magnetic	Maurice Vergnes,	City of	N. Y.	2
———,—Oscillating	C. R. Otis,	Yonkers,	"	2
——— ———	E. G. Otis,	"	"	2
———,—Rotary	K. and T. Cox,	City of	"	16
——— ———	Wm. Humphreys, Jr.,	Cold Spring,	"	2
——— ———	Frederick Kettler,	Milwaukie,	Wis.	23
Envelope Ruler,	Arthur de Witzleben,	Washington,	D. C.	23
Evaporating Pans,	H. O. Ames,	New Orleans,	La.	16
Faucets,—Measuring	Gilbert Hubbard,	Montville,	Mass.	9
Fences,	J. M. Pitts,	Sumter,	S. C.	30
———	N. M. Stratton,	City of	N. Y.	23
Filters,	T. C. Clarke,	Camden,	N. J.	9
———	M. W. Warne,	St. Louis,	Mo	9
Finger Rings,—Sheet Metal	I. M. Potter,	Providence,	R. I.	2
Fire Escape,	Wm. Breitenstein,	City of	N. Y.	9
——— ———	James Hobbs,	Columbus,	Ind.	9
——— ———,—Portable,	Israel Grafius,	Alexandria,	Penna.	2

Fire Arms,—Breech-loading	Frederick Jonas,	McConnell's Gr.	Ill.	2
———	Edward Maynard,	Washington,	D. C.	30
———	C. W. Wood,	Worcester,	Mass.	9
———,—Revolving	A. J. Gibson,	"	"	9
———	F. D. Newbury,	Albany,	N. Y.	23
———	E. A. Prescott,	Worcester,	Mass.	2
———	August Spellier,	Philadelphia,	Penna.	2
———,—Locks for	J. P. Lindsay,	City of	N. Y.	9
———,—Magazine	B. T. Henry,	New Haven,	Conn.	16
Flour Bolts,—Screens for	David Landis,	Lancaster,	Penna.	23
Forge Hammer,	Edward Pave,	City of	N. Y.	9
Freezing Liquids,—Appa's for	F. P. E. Carré,	Paris,	France,	2
Fruit Case,	Doolittle & Carson,	Oswego,	N. Y.	9
—— Driers,	H. Beamer,	Smithburg,	Penna.	9
Furnaces,	D. G. Littlefield,	Albany,	N. Y.	9
Furnace and Cooking Range,	Brown & Bridges,	Chicago,	Ill.	2
Furnaces,—Bagasse,	Jones & Charpentier,	New Orleans,	La.	23
——— for Steam Boilers,	Henry Wilkins,	Brownsville,	Penna.	2
Furniture Caster,	I. A. Stafford,	Essex,	N. Y.	23
Galvanic-Plates for Medical Use,	Joseph Hill,	Brooklyn,	N. Y.	9
Gas,—Apparatuses for Burning	R. W. Hoit,	Boston,	Mass.	9
—— Burners,	H. H. Dodge,	Georgetown,	D. C.	23
—— Fittings,—Finishing	J. W. Lyon,	Brooklyn,	N. Y.	30
—— Metres,—Dry	Gratz & Lloyd,	Philadelphia,	Penna.	23
—— Regulators,	Joseph Foster,	Richmond,	Va.	16
———	J. G. Liffingwell,	Newark,	N. J.	16
Gate and Door Swing,	F. W. Kroeber,	Forbestown,	Cal.	9
Gates,	J. H. H. Bennett,	Hunt's Hollow,	N. Y.	23
———	Hurxthal & Lee,	Boliver,	Ohio,	2
Gins,—Cotton	N. A. Patterson,	Kingston,	Tenn.	23
Gin Saws,—Filing	Samuel Yeatman,	Providence,	Ala.	16
Glass,—Manufacture of	Samuel Wetherill,	Bethlehem,	Penna.	16
Gold Separator,	J. A. Veatch,	San Francisco,	Cal.	2
Grain Bins,	Sylvester Marsh,	Roxbury,	Mass.	23
———,—Machines for Clean'g	John Outram,	Elmira,	N. Y.	30
———,—Elevat'g, Clean'g, &c.,	I. A. Stafford,	Essex,	"	23
———,—Drying	E. I. Bodrio,	St. Louis,	Mo.	2
———,——— and Cooling	J. B. Wheeler,	Chicago,	Ill.	23
——— Separators,	Landers & Lampman,	Afton,	N. Y.	16
——— Weighing Machines,	J. B. Mohler,	Pekin,	Ill.	23
———	Squeir & Preston,	Battle Creek,	Mich.	16
Hammer,—Nail	Charles Carlisle,	Woodstock,	Vt.	16
Harmonicons,—Glass or Metal	John Koppe,	City of	N. Y.	2
Harness,	S. L. Bond,	Greenwood,	S. C.	23
Harrows,	C. Watson,	Cascade,	Va.	2
———,—Rotary	Jehu Brainerd,	Cleveland,	Ohio,	2
———	S. S. Hogle,	"	"	30
Harvesters,	T. N. Foster,	Watertown,	N. Y.	2
———	F. H. Manny,	Rockford,	Ill.	2
———,—Cane	Achilles St. Dezier,	Plaquemine,	La.	9
——— ——,—Sugar-cane	Johnson & Doyle,	Philadelphia,	Penna.	2
Harvesting Machines,	S. T. Lamb,	N. Washington,	Ind.	9
———	"	"	"	2
Hat Rims,—Curling	F. S. Sibley,	Brooklyn,	N. Y.	9
Hay,—Raking and Pitching	A. J. Preston,	E. Guilford,	"	16
Heater,—Fireplace	D. S. Quimby,	Brooklyn,	"	9
Hemp Brakes,	Ezekiel Guile,	Waverly,	Mo.	16
Hoes,—Seeding	Z. B. Brown,	Simsbury,	Conn.	30
Hoops,—Straightening Bale	Charles Hughes,	New Orleans,	La.	9

Horse Shoe Machine, .	John McCarty, .	Philadelphia,	Penna.	16
Hose Protector, .	Bridges & Dieterich,	"	"	2
Ice Cream Freezers, .	J S Silva, .	Savannah,	Ga.	2
Inkstand, .	Samuel Slocomb,	Cambridge,	Mass.	2
——— .	W H Towers, .	City of	N. Y.	2
Kaleidoscope, .	McNulty & Lyman,	City of	N. Y.	2
Kegs.—Fastening for Metallic	C. L. Rehn, .	Philadelphia,	Penna.	9
Keyhole Guard, .	George Wheeler,	City of	N Y.	9
Knife Cleaner, .	Isaac Detheridge, Jr.,	"	"	23
Label Holder, .	Francis J. Collier,	Philadelphia,	Penna.	2
Ladle, with Fork Attached,	Warner & Benedict,	Bridgeport,	Conn.	16
Lamps, .	J. E. Ambrose, .	Batavia,	Ill	16
——— .	F. B. DeKeravenan, .	City of	N. Y.	23
——— .	H. W. Dopp, .	Buffalo,	"	16
——— .	Albert Kleinsteiber, .	Milwaukie,	Wis.	9
——— .	W. H. Racey, .	St Augustine,	Fla	30
———,—Submarine .	L. H. Hasse, .	City of	N. Y.	9
———,—Vapor .	W. B. Billings, .	"	"	2
Lathes, .	Lemuel Postlewait, .	Russellville,	Ohio,	16
Lifting Jacks, .	W. J. Lane, .	Chappaqua,	N. Y.	23
Leather,—Oiling .	Lewis Holcomb, .	Granby,	Conn	9
———,—Splitting,	S S Turner, .	Westborough,	Mass.	30
———,—Manufac. of Tanned	Andrew Dietz, .	City of	N Y.	16
——— Cloth,—Ornamenting	Auguste Pellet, .	Paris,	France,	2
Letter Boxes, .	G. C Jenks, .	City of	N. Y.	9
Locks,—Freight Car	J. F. Keeler, .	Cleveland,	Ohio,	2
Locomotives,—Trucks for	D. R. Pratt, .	Worcester,	Mass.	16
Lubricating Engines, &c.,	Joseph Marks, .	Boston,	"	16
Martingale Rings, .	D. C. Lockwood, .	Derby,	Conn.	2
Medicines,—Astringent	E. W. Ferris, .	Macon,	Miss.	16
Mill Bush, .	Ezekiel Casner, .	Penn Yan,	N. Y.	9
—— for Grinding Coffee,	L. S. Chichester,	City of	"	9
Mills.—Grinding .	E. J. Hyde, .	Philadelphia,	Penna.	16
——————— .	C. W. Shedd, .	Addison.	Ala.	30
Millstones,—Leveling .	D. A. Balmer, .	Lexington,	Ind.	23
———,—Ventilating	Plant & Raith, .	St. Louis,	Mo.	23
Nail Holes,—Punching .	C. C. Crosby, .	Nantucket,	Mass.	9
Ordnance,—Breech-loading	Lewis Evans, .	Morgantown,	Va.	9
———————————	T. J. Mayall, .	Roxbury,	Mass.	9
Ore Separators, .	W. O. Bourne, .	City of	N Y.	9
Paint Can, .	W. L. Gilroy, .	Philadelphia,	Penna.	9
—— Mill,	J. A. Berrill, .	Waterville,	N. Y.	9
Parasol and Fan, .	J. T Eichberg, .	City of	"	2
Peach Parer, .	W A. Coe, .	Greensboro',	N. C.	30
Pen Cleaner, .	Jonathan Warren, .	Brooklyn,	N. Y.	2
Pianofortes.	Frederick Mathushek,	City of	"	2
Picker-staff Motion, .	E H. Graham, .	Manchester,	N. H.	16
Pic-nic or Excursion Seat,	J M Perkins, .	Chicago,	Ill.	9
Pigs,—Singeing .	A. and E M. Denny,	Waterford,	Ireland,	23
Plane Bits —Securing	T M. Richardson,	Stockton,	Me.	2
Planters,—Corn .	D, J., and J. F. Herr,	Lancaster,	Penna.	9
Ploughs, .	M. G. Slemmons,	Cadiz,	Ohio,	9
——— .	J A. Stewart, .	Philadelphia,	Miss.	2
———,—Securing Points to	H D Rogers, .	Grafton,	Ohio,	9
Port Lights for Vessels, .	G. C Gourlay, .	City of	N. Y.	23
Potato Diggers, .	J. P Scudder, .	Hightstown,	N. J.	2
Presses, .	A Randel, .	City of	N. Y.	23

Press,—Bookbinders Standing	M R. Pelletreau,	City of	N. Y.	2
——.—Copying .	Cyrus Chambers, Jr.,	Philadelphia,	Penna.	2
——,—Cotton .	R. M. Brooks, .	Greenville,	Ga.	2
——.—— .	Solon Dike, .	Columbus,	S C.	16
Presses,—Cotton, .	P. G. Gardiner, .	City of	N. Y.	23
—————— .	Murdoch Murchison, .	Denmark,	Tenn.	23
——————— .	Robert Scott, Jr.,	Madison,	Ind.	9
Press,—Packing .	J. Y. Parce, .	Fairport,	N. Y.	9
Printing Addresses on Papers,	Samuel Soule, .	Cincinnati,	Ohio,	2
——,—Plate .	W. H. Oakes, .	City of	N. Y.	23
—— Press Feeder,	Henry Barth, .	Cincinnati,	Ohio,	23
——— .	Wm H. Babcock, .	Homer,	N. Y.	23
Prophylatic Remedies,	C. H. Thomas, .	New Orleans,	La.	16
Propeller, .	C. J. Schueder, .	Astoria,	N. Y.	9
Propellers as applied to Vessels,	Henry Stanley, .	Troy,	"	9
Propelling by Horse Power,	Isaac Stoddard, .	Great Bend,	Penna.	9
Pumps, .	John Holmes, .	St Clair,	"	2
—— .	W. J Johnson, .	Newton,	Mass.	23
—— .	M. E. Rudasill, .	Shelby,	N. C.	9
—— .	S. D Stout, .	Charleston,	Tenn	9
Punches, .	R. Humphrey, .	Unionville,	Conn.	16
Quartz Crusher & Amalgamator,	F. B. Abbott, .	St. Louis,	Mo.	9
——,—Crushing and Pulver.	T. A. Morris, .	Green Bay,	Wis.	23
Railroad Cars,—Bearings for	D. R. Pratt, .	Worcester,	Mass.	30
—— —— over Obstructions,	P. I. Biderman, .	Philadelphia,	Penna.	9
———,—Heating	Joseph Pine, .	City of	N. Y.	9
—— ———,—Metallic	J. A. Roebling, .	Trenton,	N. J.	16
Railroads,—Propelling Cars on	James A. Bennet, .	King's County,	N. Y.	9
Railroad Car Seats and Couches,	Edward Burke, .	Philadelphia,	Penna.	23
———————	J. H. Fisher, .	Placerville,	Cal	23
——— Cars,—Transferring	Josiah Ashenfelder,	Philadelphia,	Penna.	9
———,—Ventilation of	Charles Newcomb, .	City of	N. Y.	9
———————	R B. Wright, .	Norfolk,	Va.	23
——— Chairs, .	D. A. Hopkins, .	Bergen,	N. J.	23
Rakes,—Hay .	S. J. Homan, .	Walden,	N Y.	2
Reapers and Mowers, .	G. A. Stephenson, .	Paw Paw,	Mich.	2
Reaping and Mowing Machines,	McClintock Young, Jr.,	Frederick,	Md.	2
Refrigerators, .	Thomas Byrne, .	Baton Rouge,	La.	23
Rice Hulling Machines,	Daniel Lombard,	Boston,	Mass.	23
Rivers,—Delineating Course of	H. Collier, .	Smithville,	Ark.	30
Roofing Purposes,—Compos. for	J P. Gay, .	Cincinnati,	Ohio,	2
Sabre-bayonet Fastening	C. A. McEvoy, .	Richmond,	Va.	30
Saddles, .	John Commins, .	Charleston,	S C.	2
Sates,—Burglar Proof .	J. R. Floyd, .	City of	N Y.	16
Sash Fastener, .	P. A Gladwin, .	N. Providence,	R. I.	2
——— .	Sylvenus Walker, .	Boston,	Mass.	9
Saws, .	Darwin Talbot, .	Ironton,	Mo.	2
Saw-grinding Machine, .	J. D. Custer, .	Norristown,	Penna.	2
Saws,—Grinding Circular	John Andrews, .	Elmira,	N. Y.	2
——,—Adjusting Rake of Muley	C. W Griffith, .	Dayton,	Ohio,	23
Saws,—Adjusting Rake of Recip.	J. J. Watson, .	Buffalo,	N. Y.	23
Sawing Machines, .	J. C. Climo, .	Camden,	N. J.	23
Scumming,—Apparatus for	Titus Molinier, .	New Orleans,	La.	9
Seed Planters, .	Pollock & Sener, .	Fredericksb'gh,	Va.	9
———,—Cotton .	J. T. Ham, .	Senatobia,	Miss.	9
Seeding Machines,	J. B. Duane, .	Schenectady,	N. Y.	2
——— .	W. M. Garee, .	Cox,	Ohio,	9
Sewing Machines,	George Fetter, .	Philadelphia,	Penna.	23
——— .	A. F. Johnson, .	Boston,	Mass.	23
Shaft Tug, .	Brown & Babcock,	New Haven,	Conn.	23
Shafting,—Hanger for .	James P. Collins, .	Troy,	N. Y.	2

Shaftings,—Hangers & Boxes for	Wm. Watts,	Newark,	N. J.	30
Sheet Metal,—Bending	Henry Evans, Jr.,	Baltimore,	Md.	30
———,—Square Pans of	E. M Roxford,	Indianapolis,	Ind.	30
Shingle Machines,—Tilt. Tables	J. B. Suitt,	"	"	9
Ships Blocks,—Straps of	Eugene Mack,	U. S. A.		30
Shovels,—Straps for Handles of	C. H. Sayre,	Utica,	N. Y.	16
Skates,	J. F. Blondin,	Niagara Falls,	"	2
———	E. H. Graham,	Manchester,	N. H.	2
Skate,—Self-adjusting	L. J. Masterson,	Newton,	Mass.	2
Skirts,	Wm. Heppenstall,	Springfield,	"	30
Slivering Machines,	H. L. Nichols,	City of	N. Y.	16
Smut Machines,	H. L. Pierce,	Millpont,	"	30
Sowing Machines,	Rowland Chapman,	Darlington Dis.	S. C.	16
———	D C. Teller,	Beaver Dam,	Wis.	16
Spoke Machines,	John Gilchrist,	Berlin City,	"	23
Spool Stand,—Revolving	J. P. and F. V. Wilson,	Ilion,	N. Y.	23
Spring,—Carriage	Pressey & Sheets,	Suisun City,	Cal.	16
———,—India Rubber Car	T. F. Allen,	Dyersville,	Iowa,	23
Stalks, &c.,—Cutting	M. E Rudasill,	Shelby,	N. C.	23
———,—Pulling and Cutting	Henry Snyder,	Dayton,	Ohio,	9
Staves,—Planing	Jean de Libatcheff,	Yaroslawl,	Russia,	2
Steam Boiler,	Smith & Mars,	City of	N. Y.	2
——— Boilers,—Prev. Incrust.	Webster & Young,	Portsmouth,	Va.	23
——— ———,—Safety Appa's	Charles McCarthy,	City of	N. Y.	9
——— Engines,	C. C. Barton,	Troy,	"	9
———,—Pistons for	Robinson & Clark,	Bellaire,	Ohio,	9
———,—Valve Seats	C. B. Long,	Worcester,	Mass.	2
———,——— for	G. W. Van Deren,	Big Flatts,	N. Y.	9
———	H. E. Woodford,	Watertown,	"	30
———	A. J. Laird,	Middletown,	Penna.	9
———,—Pistons for	T. S. La France,	Elmira,	N. Y.	9
———,—Regulator for	J. A. Burnap,	Albany,	"	16
——— Gauge,	Grader & Wursbach,	Memphis,	Tenn.	9
——— Generators,	John Johnson,	Biddeford,	Me.	9
——— Valves,	J. F. Letellier,	Grand Rapids,	Mich.	23
Stencil Printing Machine,	A. J. Fullam,	Springfield,	Vt.	2
Stirrups,	D. W. Clark,	Stratford,	Conn.	9
———	J. R Williamson,	Washington,	D. C.	9
Stone,—Dressing	Abijah Smith,	Kingston,	N. Y.	23
Stoves,—Cooking	Miles Pratt,	Watertown,	Mass.	23
———	G. G. Wolfe,	Troy,	N. Y.	23
Stove Radiators,	Crossman & Brown,	Warren,	Mass.	9
Stoves and Ranges,—Cooking	S B. Sexton,	Baltimore,	Md.	2
Straw Cutters,	J. A. and G. W. Cowdery,	N. Middletown,	Ky.	30
———	J. H. Lilly,	Bardstown,	"	16
Sugar,—Box for Dropping	A. T. Ballantine,	City of	N. Y.	23
Tanning,	Crane & Baldwin,	Anamosa,	Iowa,	16
———	Andrew Dietz,	City of	N. Y.	16
———	Robert Harper,	Trumbull,	Ohio,	2
———,—Compositions for	J. L. Wells,	St. Louis,	Mo.	9
Tiles for Flooring	T. J. Mavall,	Roxbury,	Mass.	16
Tires,—Shrinking	A. P. Cassel,	Wataga,	Ill.	16
Tool Holder,	Silas Stevens,	Worcester,	Mass.	30
Tools,—Sharpening	J. C. Cooke,	Middletown,	Conn.	2
Traps,—Animal	H. Y. Wildey,	Philadelphia,	Penna.	2
Type,—Setting	Dorsey & Mathers,	Fairmount,	Va.	2
——,—Casting Embossed	I. C. Bryant,	Philadelphia,	Penna.	9
Uterine Supporters	Gustavus Kleinwort,	Albion,	Ill.	16
Vehicles,—Running Gear of	F. L. Kidder,	Brooklyn,	N. Y.	23
———-,—Two-wheeled	J. W Barnes,	Murfreesboro',	N. C.	23
———-,—Velocipede	S. W. Barr,	Mansfield,	Ohio,	2

Warp,—Machines for Dressing	Robert Pilson,	Laurel,	Md.	30
Wash Bench,	Samuel Wiswell,	Hyde Park,	Vt.	9
Washing Machine,	John Gray,	Melrose,	N. Y.	9
———	Phelps & Wright,	Sycamore,	Ill.	2
———	J. B. Coffin,	Hayesville,	Ohio,	23
———	S. T. Lamb,	N. Washington,	Ind.	16
———	A. F. Lapham,	City of	N. Y.	9
Watches,	G. P. Reed,	Roxbury,	Mass.	2
Water Closets,	Wm. S. Carr,	City of	N. Y.	23
——— from Wells,—Elevating	S. and A. Aldrich,	Washington,	D. C.	23
———	John McArthur,	Aurora,	Ill.	23
——— Wheel,	J. J. Watson,	Buffalo,	N. Y.	2
Wheels,—Car	G. S. Bosworth,	Troy,	"	23
———,—Carriage	Johnson & Gibson,	Boston,	Mass.	23
———,—Hubs for	N. T. Edson,	New Orleans,	La.	16
———,—Moulding Cast Iron	G. S. Bosworth,	Troy,	N. Y.	30
Window Fastener,	E. M. Judd,	New Britain,	Conn.	16
——— Blind Fasteners,	A. T. Finch,	Meriden,	"	16
——— Net and Sash,	Isaac Wiswell,	Springfield,	Vt.	9
——— Sash Supporters,	L. Y. Gardiner,	Amsterdam,	N. Y.	9
———	James McMahan,	Amelia,	Ohio,	9
Winnowing Machines,	F. H. Manny,	Rockford,	Ill.	9
Wood-bending Machines,	D. B. Hedden,	Newark,	N. J.	16
Wrench,—Screw	G. C. Taft,	Worcester,	Mass.	16
Wrenches,—Wagon	P. D. Van Hoesen,	City of	N. Y.	2

ADDITIONAL IMPROVEMENTS.

Fire Arms,—Tape Primer for	T. T. S. Laidley,	U. S. A.		9
Lamps,	G. T. Parkhurst,	Baltimore,	Md.	2
Paper and Letter File,	J. B. McEnally,	Clearfield,	Penna.	2
Ploughs,	W. H. Johnson,	Richmond,	Ark.	2
Watch Key and Guard Bar,	D. F. Elmer,	Haydensville,	Mass.	2

RE-ISSUES.

Door Plates,	J. W. Bliss,	Hartford,	Conn.	16
Egg Beater,	E. P. Monroe,	City of	N. Y.	16
Fire Arms,—Breech-load. (2 pat.)	Edward Lindner,	"	"	2
———,—Revolving	Smith & Wesson,	Springfield,	Mass.	9
Harrows,	D. W. Shares,	Hamden,	Conn.	9
Harvester Rakes,	Owen Dorsey,	Dorseyville,	Md.	23
Heating Ores,	A. C. Vandyke,	Greenupsburg,	Ky.	2
Horse-shoe Nails,	Amos Whittemore,	Cambridgeport,	Mass.	9
Ice,—Hoisting and Storing	Steenburgh & Egnor,	Catskill,	N. Y.	23
Locks,	T. L. Pye,	City of	"	16
Needle Case and Index,	C. D. Wheeler,	Bridgeport,	Conn.	16
Paper and other Fabrics,—Dry'g	E. L. Perkins,	Roxbury,	Mass.	9
Railroad Cars,	S. J. Seely,	City of	N. Y.	2
Refrigerator,	B. M. Nyce,	Kingston,	Ind.	23
Saws,—Grinding	H. R. Burger,	Richmond,	Va.	16
Seeders,—Percussion	J. R. Rogers,	Sacramento,	Wis.	9
Steam Boilers,	Louis Lefebre	New Orleans,	La.	16

DESIGNS.

Carpets,	E. J. Ney,	Lowell,	Mass.	2
Carpeting, &c. (13 cases),	H. G. Thompson,	City of	N. Y.	2
Centre Pieces,	Henry Berger,	"	"	2
Hat,—Lady's	E. A. Murdoch,	Boston,	Mass.	2
Heater Fronts,	Elias Tompkins,	Brooklyn,	N. Y.	9
Spoons,	Alonzo Hebbard,	City of	"	2
Stoves,	Sailor & Steffe,	Philadelphia,	Penna.	9
———	Smith & Brown,	"	"	2
Stove,—Plates of a Cooks	"	"	"	2
—— Register,	N. S. Vedder,	Troy,	N. Y.	2

FRANKLIN INSTITUTE.

Proceedings of the Stated Monthly Meeting, December 20, 1860.

John Agnew, Vice-President, in the chair.

Isaac B. Garrigues, Recording Secretary.

The minutes of the last meeting were read and approved.

Two letters from the Royal Academy of Science, of Lisbon, Portugal, were read.

Donations to the Library were received from the Commissioners of Patents, the Royal Geographical Society, the Chemical Society, and the Institute of Actuaries, London, Charles Atherton, Esq., Woolwich, and the Literary and Philosophical Society, Liverpool, England; the Ecole des Mines, and the Société d'Encouragement pour l'Industrie Nationale, Paris, and the Société Industrielle, Mulhouse, France; the Académie Royale des Sciences de Lisbonne, Portugal; L. A. Huguet-Latour, Montreal, Canada; the Board of Supervisors, San Francisco, California; the Smithsonian Institute, and F. Emmerick, Esq., Washington City, D. C.; Henry R. Campbell, Esq., Burlington, Vt.; and Profs. John C. Cresson, and John F. Frazer, Philadelphia.

The Periodicals received in exchange for the Journal of the Institute, were laid on the table.

The Treasurer's statement of the receipts and payments for the month of November was read.

The Board of Managers and Standing Committees reported their minutes.

Thirty-one resignations of membership in the Institute were read and accepted.

Candidates for membership in the Institute (6) were proposed, and the candidates proposed at the last meeting (14) duly elected.

Nominations were made for Officers, Managers, and Auditors of the Institute for the ensuing year.

Resolved, That the polls for receiving the votes of the members at the annual election for Officers, Managers, and Auditors for the ensuing year, to be held on the third Thursday of January next, be opened at 4 o'clock, P. M., and closed at 8 o'clock, P. M.; and that seven members be appointed by the President to receive the votes and report the results thereof.

Dr. Green exhibited his "Patent Lamp for Burning Fluid;" and, in a series of experiments, showed the impossibility of exploding it. The burning fluid is vaporized by the heat of a spur, reaching downwards into the wick, which is contained in a strong brass tube about seven inches long. The tube is surmounted by a metal cap, having four or more small holes for the emission of the vaporized fluid, at which places it is lighted. This lamp will burn only when in an upright position; if inclined considerably, or inverted, as it probably would be in falling, if the top is removed for the purpose of replenishing the supply, or, the tube taken hold of by the fingers, the flame is instantly extinguished.

Mr. T. Shaw exhibited his Gas-light Cooking Stove, designed to

burn the ordinary carburetted-hydrogen gas that is used for lighting purposes. Mr. Shaw said that this invention, patented Dec. 14, 1858, is designed as a complete substitute for the common coal stove as a cooking apparatus. The construction of the burner is conical, with a gauze disk extending from its smaller end, or outlet for the passage of the gas (which passage is also covered with gauze), for the purpose of supporting the flame, and giving an additional supply of air or oxygen. The first supply is given in the conical chamber, the base of which is open to the external air. The gas on entering said chamber is caused to pass over an inverted cone, which spreads the gas in a thin sheet, and tends to give a current favorable for taking a large supply of air.

The oven, which is placed immediately over one of these burners, is of a cylindric form, and of a capacity of from one to six pies, constructed of an inner and outer casing. The heat from the burner comes in immediate contact with the material to be cooked or baked, and from thence, the cooler currents descending, is caused to ascend from the bottom between the inner and outer casing, and over to the centre of the top of the oven, where there is an opening for its exit.

This stove without any alteration in the result, is modified to suit the many places where it is applicable. The one designed for family use is not very unlike the coal stove in appearance (save that it is much lighter and neater), having a large oven for baking, and places in front for boiling, frying, ironing, &c. It will bake, boil, roast, &c., in the same time as can be done in any stove. The cost is not greater than other fires when not used between meals. The object was first to generate heat with economy, and afterwards to use it with economy.

Any further information will be given on applying to Thomas Shaw, 243 Race Street.

Mr. Alsop exhibited one of his Car Springs, which had been in use on a city passenger car.

BIBLIOGRAPHICAL NOTICE.

Lessons and Practical Notes on Steam, the Steam Engine, Propellers, &c., &c.; for young Marine Engineers, Students, and others. By the late W. H. King, U. S. N. Revised by Chief Engineer J. W. King, U. S. N. New York: Frederic A. Brady, 24 Ann St., 1860. 8vo., pp. 168.

This is an excellent little work, of much more merit than its modest title-page pretends to. Its scientific explanations are uncommonly clear and easily understood, and it avoids entirely the too frequent affectation of elaborate mathematical formulæ, which so often render works of this class distasteful and incomprehensible to the persons for whom they are intended.

The subjects treated of are those interesting to practical steam engineers, and they are treated lucidly and with sufficient thoroughness for practical purposes. We would note with especial approbation the

chapters on the Indicator, and on Paddle-wheels and Propellers, as containing a great deal of valuable information, not only for students, but for men of advanced attainments.

We hope the book, which is well got up and printed, and illustrated with wood-cuts, will meet with the success to which its merits entitle it. F.

METEOROLOGY.

For the Journal of the Franklin Institute.

The Meteorology of Philadelphia. By JAMES A. KIRKPATRICK, A.M.

THE PRESSURE OF THE ATMOSPHERE.—A period of nine years and six months is insufficient to ascertain the laws of atmospheric pressure. Nevertheless, from observations made regularly and carefully for that time, we may perceive some indication of the laws fixed by the Creator for the government of the atmosphere in which we live. The air is of such extreme mobility that a very slight force produces changes in it which may affect the health and even the life of those who must necessarily be exposed to its influence.

The air, though invisible, is a material substance, and possesses many of the physical properties of the solid and liquid bodies, such as weight, inertia, elasticity, capacity for heat, &c. The weight or pressure of the air may be made manifest to the senses by weighing a vessel filled with it, and again weighing it after the air has been removed by the air pump; or it may be shown by a small disk of leather, which, being moistened and pressed against any smooth surface, so as to expel the intervening air, will adhere to the smooth surface with great force, caused by the pressure of the air upon it. If the air be removed from a tube which has one end closed, and the other end be immersed in water or any other fluid, the pressure of the atmosphere will force the fluid up the tube to a certain height. At the surface of the sea, water will be found to rise in the tube under such circumstances to a height of about 33 feet, while mercury will rise only 29 or 30 ins. If the air has been entirely removed from the tube, the weight of the column which is above the surface of the fluid, in the vessel in which the experiment is made, will be found to be equal, no matter what the fluid used may be. In fact it will always be equal to the weight or pressure of the air which causes it to rise; that is, to the weight of a column of air extending from the surface of the vessel to the top of the atmosphere. This has been found to be about 15 pounds on every square inch. It is evident that if the top of the atmosphere was always at the same distance above the instrument, the column in the tube would a ways remain at the same height. But if, by any means, the height of the column should be changed, it will of course produce a corresponding change in the height of the fluid in the tube; that is, if the height of the atmosphere is increased, the temperature remaining the same, its weight will be increased, and consequently its increased pressure upon the fluid in the vessel will cause that in the tube

to rise higher. The barometer is an instrument constructed on the principle of the tube in these experiments.

There are several circumstances by which the height of the atmosphere above the barometer may be changed. The instrument may be removed from the level of the sea to the top of a mountain, when, being nearer the top of the atmosphere, the column of mercury in the tube will have a smaller pressure to sustain, and it will not rise as high as it did at the surface of the sea. Or, if the barometer remains in the same position, the distance to the top of the atmosphere, and consequently its pressure upon the instrument, may be changed by a change of temperature, by the passage of a storm, or by other means.

TABLE I.—*Showing the mean height of the barometer at the hours of observation at Philadelphia, as deduced from observations continued for nine years and a half, reduced to the freezing point, but not corrected for altitude.*

Months.	7 A. M.	2 P. M.	9 P. M.	Monthly means.
January,	29·978	29·940	29·965	29·961
February,	29·915	29·867	29·896	29·892
March,	29·845	29·789	29·821	29·818
April,	29·800	29·758	29·787	29·782
May,	29·843	29·809	29·830	29·827
June,	29·825	29·791	29·803	29·806
July,	29·861	29·831	29·846	29·846
August,	29·879	29·851	29·869	29·866
September,	29·985	29·943	29·961	29·963
October,	29·937	29·895	29·915	29·916
November,	29·935	29·896	29·921	29·917
December,	29·953	29·916	29·939	29·936
Annual Means,	29·893	29·854	29·877	29·875
Winter,	29·949	29·908	29·932	29·930
Spring,	29·829	29·785	29·813	29·809
Summer,	29·859	29·828	29·844	29·844
Autumn,	29·952	29·911	29·932	29·932

In consequence of the ease with which masses of air move from one place to another, the barometric column is incessantly oscillating. These changes are not, however, accidental, but seem to follow certain fixed laws, which at present are but partially known. There is a daily pulsation or oscillation in the pressure of the atmosphere, showing two maxima and two minima in the course of 24 hours. The maxima occur about 10 A. M. and 10 P. M., and the minima at about 4 A. M. and 4 P. M. The above table shows the height of the barometric column for the three hours of observation, as deduced from observations made at Philadelphia for nine years and six months. The barometer used was made by Francis for the Committee on Meteorology of the Franklin Institute. It has a flexible leather bottom and is furnished with a short brass scale. It has been frequently compared with a standard instrument and is believed to be perfectly reliable. The height of the fountain of the barometer above mean tide in the River Delaware is fifty feet; and the geographical position of my residence, where the

observations were made, as fixed by the determinations of the Coast Survey and by measurement, is lat. 39° 57′ 28″ N., long. 75° 10′ 28″ W. from Greenwich. The observations have all been reduced to the temperature of 32° Fah., but have *not* been reduced to the level of the sea.

Though these observations were not made at the hours of daily maxima and minima, yet they show very clearly a regular wave or pulsation of the atmospheric pressure, greater at the morning and evening, and less at the mid-day observations. They also show that the height of the barometric column at 9 P. M. is very near the average height of the three observations; the difference of the two for the whole period of nine years and a half being only two one-thousandths of an inch.

TABLE II.—*Showing the mean daily range of the barometric column at Philadelphia for every month, season, and year, from July,* 1851, *till December,* 1860.

Months.	1851.	1852.	1853	1854.	1855.	1856.	1857.	1858.	1859.	1860	Mean
	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch	Inch.	Inch.	Inch.
January,		·202	·196	·249	·206	207	·220	·208	·206	·159	·206
February,		·286	·205	·251	·159	·228	·180	·190	·230	·209	·215
March,		·241	·194	·195	·174	·165	·200	·171	·250	·133	·191
April,		·175	·208	·221	·165	·180	·188	·150	·160	·166	·179
May,		·133	·120	·091	·095	·133	·144	·158	·111	·100	·121
June,		·120	·089	·081	·125	·083	·094	·072	·116	·088	·096
July,	·110	·110	·082	·079	·086	·095	·070	·094	·099	·112	·094
August,	·076	·082	·089	·083	·131	·092	·115	·095	·070	·090	·092
September,	·114	·124	·121	·130	·135	·082	·109	·135	·119	·143	·121
October,	·151	·149	·170	·135	·131	·133	·161	·143	·140	·119	·143
November,	·249	·204	·193	·188	·187	·147	·181	·136	·193	·197	·187
December,	·218	·266	·171	·174	·261	·225	·205	·206	·199	·196	·212
Annual range,		·174	·153	·156	·155	·147	·156	·146	·158	·143	·154
Winter,		·235	·222	·224	·180	·232	·208	·201	·214	189	·212
Spring,		·183	·174	·169	·145	·159	·177	·160	·174	·133	·164
Summer,		·104	·087	081	·114	·090	·093	·087	·095	·097	·094
Autumn,	·171	·159	·161	·151	·151	·121	·150	·138	·151	·153	·151

Besides this hourly wave of pressure, we also notice a daily undulation in comparing a day with that which immediately precedes it. This daily change of pressure at Philadelphia for the different months, seasons, and years, is exhibited in the second table, which contains the mean daily range of the barometric column. This table is prepared by comparing one day's observations with those of the same hours of the preceding day. For example, if the corrected height of the mercury on Monday is, at 7 A. M., 29·786 ins., at 2 P. M., 29·698 ins., and at 9 P. M., 29·892 inches, and on Tuesday at the same hours respectively, 30·325, 30·252, and 30·320 inches, then the mean daily range for Tuesday would be the mean of the differences for each hour taken separately. The difference at 7 A. M. is ·539 inch, at 2 P. M., ·554 inch, and at 9 P. M., ·428 inch, and the average of these three numbers, ·507, is the mean daily range of the mercury for Tuesday.

The mean for the month is obtained by combining the means for all the days of the month; the mean for the seasons by combining the means for the three months composing the season; and that for the year by taking the average of the twelve monthly means.

It will be seen by inspecting the table that the mean daily range changes regularly with the months and seasons; it being greater in the winter months and less in summer, while the average for the different years remains nearly stationary.

The third table indicates a wave of pressure extending over a still greater period of time, but on being referred to months and seasons agreeing remarkably with the indications of the mean daily range.

TABLE III.—*Showing the extreme monthly, annual, and quarterly oscillation of the barometric column at Philadelphia, from July,* 1851, *till December,* 1860, *inclusive.*

Months.	1851.	1852.	1853.	1854.	1855.	1856.	1857.	1858.	1859.	1860.	Mean.
	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.
January,		1·458	1 763	1·087	1·447	1·115	1·275	1·121	1·088	·806	1·210
February,		1 350	1 278	972	·664	1·243	1·039	·849	·913	1·259	1·063
March,		1·299	1·025	1·102	·962	·928	1·075	965	1·145	·725	1·025
April,		1·126	·994	1 269	·945	·996	1 077	·724	1·193	·984	1·034
May,		·806	·797	·568	·675	·755	·791	·861	·664	·571	·721
June,		·849	·480	·549	·625	·501	·712	·436	·632	·880	629
July,	·577	·678	·537	·407	·490	·468	·602	·590	·658	·484	·549
August,	·582	·564	·500	·484	·741	·690	·501	·518	·327	·394	·533
September,	·776	·869	·700	·731	·601	·641	·614	·874	·841	·716	·737
October,	·720	·819	·819	·891	·732	·652	1.187	·936	·723	·963	·844
November,	1·396	1·055	1·035	1·112	·898	1·133	1.356	·630	·902	1·057	1·057
December,	·989	1·079	1·173	1·260	1·499	1 578	1.140	1·253	·900	1·133	1·200
Annual oscillation,		1·687	1·763	1·360	1·664	1·578	1·626	1·325	1·585	1·319	1·545
Winter,		1·620	1·763	1·356	1·447	1·499	1·578	1·265	1·269	1·300	1·455
Spring,		1·638	1·114	1·360	1 038	1·039	1 141	·965	1·145	·984	1·158
Summer,		·719	·629	·636	·860	·698	·889	·590	·682	·880	·736
Autumn,	1·396	1·131	1·035	1·131	·898	1·133	1·461	·975	1·000	1·065	1·122

Table III. contains the monthly, annual, and quarterly oscillations of the barometric column. It is prepared by taking the difference between the highest and lowest stand of the mercury for each month, each year, and each quarter. The numbers given are probably less than the actual difference, as they, generally, only indicate results obtained by three daily observations (at 7 A. M., 2 P. M., and 9 P. M.), and the actual maximum and minimum may have been reached and passed at some other hour of the day. They show, however, a distinct pulsation or wave of barometric disturbances, which reaches its maximum in January and its minimum in August, following a pretty regular curve from month to month. This wave is seen more distinctly in comparing the various seasons. The average oscillations for the summer are only about half as great as for the winter, while the disturbances for the spring are but slightly greater than for the autumn. The greatest oscillation of the mercury for any one year was 1·763 inches in 1853. The lowest stand of the mercury observed was 28·884

inches on the 21st of April, 1852, and the highest was 30·704 inches on the 28th of January, 1853, so that the total oscillation for the time of observation is 1·82 inches.

But there are indications of still greater atmospheric pulsations. By inspecting the fourth table, containing the average height of the barometric column for every month, it will be seen that, with the exception of the month of September, the means for the different months for the series of years there given, form a regular curve, which attains its greatest height in January, descends rapidly till April, and then rises gradually again till December or January; or perhaps there may be a double wave, the first or great undulation extending from January till September, and then a smaller one from September till January. The number of years over which this series of observations extends not being great enough to determine this point with accuracy.

Again, the line of annual means in Table IV. indicates a barometric wave or pulsation extending probably over a period of nine or ten years. It will be seen that the annual mean of 1853 appears to be a maximum, that the means for the ensuing years descend gradually until they reach a minimum in 1856, or between 1856 and 1857, and then again begin to rise, forming a curve of such a shape as to indicate another maximum about the year 1862 or 1863. It will, however, require a longer period of observation before the truth of such a law can be ascertained.

TABLE IV.—*Average height of the barometric column at Philadelphia for every month, season, and year, from July, 1851, till December, 1860, reduced to the freezing point, but not corrected for altitude. Height above mean tide 50 feet.*

Months.	1851.	1852.	1853.	1854.	1855.	1856.	1857.	1858.	1859.	1860.	Means.
	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.
January, .		29·880	29·862	30·008	29·971	29·879	30·062	29·951	30·003	29·941	29·961
February, .		29·857	29·930	29·957	29·840	29·731	30·034	29·874	29·885	29·924	29·892
March, .		29·887	29·873	29·841	29·797	29·773	29·836	29·807	29·758	29·794	29·818
April, .		29·638	29·850	29·870	29·856	29·814	29·733	29·751	29·701	29·824	29·782
May, .		29·876	29·888	29·849	29·807	29·785	29·748	29·805	29·874	29·810	29·827
June, .		29·844	29·988	29·824	29·739	29·781	29·663	29·813	29·861	29·740	29·806
July, .	29·743	29·900	29·955	29·925	29·851	29·809	29·808	29·827	29·852	29·791	29·846
August, .	29·868	29·952	29·912	29·946	29·923	29·765	29·811	29·829	29·827	29·832	29·866
September, .	30·034	30·028	29·975	30·021	29·982	29·886	29·936	29·922	29·858	29·989	29·963
October, .	29·883	29·975	29·975	29·994	29·831	29·982	29·830	29·906	29·845	29·936	29·916
November, .	29·914	29·921	30·159	29·833	29·948	29·956	29·883	29·797	29·965	29·797	29·917
December, .	30·020	29·971	29·868	29·885	29·919	29·961	29·899	29·974	29·926	29·939	29·936
Annual means,		29·894	29·945	29·913	29·872	29·834	29·857	29·855	29·863	29·859	29·875
Winter, .		29·919	29·954	29·944	29·899	29·840	30·019	29·908	29·954	29·930	29·930
Spring, .		29·800	29·870	29·853	29·820	29·791	29·772	29·788	29·778	29·809	29·809
Summer, .		29·899	29·955	29·898	29·838	29·785	29·760	29·823	29·847	29·788	29·844
Autumn, .	29·944	29·975	30·036	29·949	29·920	29·941	29·883	29·874	29·889	29·906	29·932

NOVEMBER.—The temperature of November was about one degree above the average for the last ten years, and one degree below the temperature of November, 1859. The warmest day was the first, of which the mean temperature was 69°, and the thermometer indicated the maximum (80°) on the same day. The 25th of the month was the coldest day, the mean temperature being 23·3°. The minimum temperature (16°) occurred on the morning of the same day. The maximum temperature was higher, and the minimum lower, than for any

previous month of November for the ten years of observation. The nearest approach to such a condition was in November, 1857, when the highest temperature was 78° and the lowest 19°. The temperature was at or below the freezing point on six days of the month.

The first ice of the season was observed on the morning of the 21st, and the first snow occurred on the afternoon of the same day. The ice was less than the tenth of an inch in thickness, and the snow continued only for a few minutes.

Rain fell on twelve days to the aggregate depth of 6·057 inches, which is about twice the usual quantity for the month, and the greatest amount for November during the period for which the observations have been taken. In November, 1852, 6·050 inches fell, which is the nearest approach to the rain of last November. Nearly one-half of the amount of rain for the month fell on the 3d. On that day 2·998 inches fell.

The force of vapor at 2 P. M. was less than usual, but at 7 A. M. and 9 P. M. it stood at about the average of the same hours for the last ten years. The relative humidity was again below the average.

The pressure of the atmosphere was less than usual, being twelve-hundredths of an inch less than the average for ten years, and nearly two-tenths of an inch less than it was in November, 1859.

A Comparison of some of the Meteorological Phenomena of November, 1860, with those of November, 1859, and of the same month for ten years, at Philadelphia.

	Nov., 1860.	Nov., 1859.	Nov., 10 years.
Thermometer.—Highest,	80°	67°	80°
" Lowest,	16	27	16
" Daily oscillation,	14·43	18·60	13·41
" Mean daily range,	5·53	7·30	5·77
" Means at 7 A. M.,	43·30	42·63	41·23
" " 2 P. M.,	50·53	53·35	50·53
" " 9 P. M.,	45·33	46·48	44·45
" " for the month,	46·39	47·49	45·40
Barometer.—Highest,	30·305 in.	30·338 in.	30·661 in.
" Lowest,	29·348	29·436	29·117
" Mean daily range,	·197	·193	·187
" Means at 7 A. M.,	29·821	29 990	29·935
" " 2 P. M.,	29·773	29·940	29 896
" " 9 P. M.,	29·792	29·965	29 921
" " for the month,	29·795	29·965	29·917
Force of Vapor.—Means at 7 A. M.,	·234 in.	·227 in.	·231 in.
" " " 2 P. M.,	·228	·241	·234
" " " 9 P. M.,	·236	·241	·238
Relative Humidity.—Means at 7 A. M.,	76 per ct.	77 per ct.	78 per ct.
" " " 2 P. M.,	57	56	59
" " " 9 P. M.,	71	71	74
Rain: amount in inches,	6·057	3·796	3·680
Number of days on which rain fell,	12	8	10
Prevailing winds,	N.81°25′W·333	N.54°52′W·206	N.67°59′W·245

The sky was clear or free from clouds on four days of the month, and there were six days on which the sky was completely covered with clouds at the hours of observation.

AUTUMN.—The Autumn, comprising the months of September, October, and November, was one degree warmer than the autumn of 1859, and very near the average temperature for the last ten years.

The pressure of the atmosphere was greater than for the Autumn of 1859, but it still continued to be less than the average.

The force of vapor was greater than for the preceding Autumn, but it was still less than the average; while the relative humidity was almost precisely the same as for the Autumn for ten years, as will appear by an examination of the annexed table of comparisons.

The rain was about one inch less than fell in the Autumn of 1859, but it was three inches and a half above the average.

The number of days on which rain fell was 32, being five more than usual.

The prevailing winds during this Autumn came from a point a little south of west, while their average direction for ten years is about twice as far north of west.

A Comparison of the AUTUMN *of* 1860, *with that of* 1859, *and of the same season for ten years, at Philadelphia.*

	Autumn, 1860.	Autumn, 1859.	Autumn, for 10 years.
Thermometer.—Highest,	92°	82°	95°
" Lowest,	16	27	16
" Daily oscillation,	16·23	18·30	15·35
" Mean daily range,	5·50	5·78	5·37
" Means at 7 A. M.,	51·72	50·21	51·59
" " 2 P. M.,	62·33	61·78	62·82
" " 9 P. M.,	54·99	54·00	55·42
" " for the autumn,	56·35	55·33	56·61
Barometer.—Highest,	30·313 in.	30·338 in.	30·661 in.
" Lowest,	29·218	29·338	29 012
" Mean daily range,	·153	·151	·151
" Means at 7 A. M.,	29·929	29·910	29·952
" " 2 P. M.,	29·881	29·866	29·911
" " 9 P. M.,	29·909	29·893	29·932
" " for the autumn,	29·906	29 889	29·932
Force of Vapor.—Means at 7 A. M.,	·327 in	·308 in.	·339 in.
" " " 2 P. M.,	·343	·326	·357
" " " 9 P. M.,	·348	·331	·356
Relative Humidity.—Means at 7 A. M.,	78 per ct.	77 per ct.	78 per ct.
" " " 2 P. M.,	56	55	57
" " " 9 P. M.,	74	72	74
Rain, amount in inches,	13·649 in.	14·785	10·208
Number of days on which rain fell,	32	26	27
Prevailing winds,	s. 84°34′w·254	s 69°12′w·281	s 77°39′w·237

Abstract of Meteorological Observations for October, 1860; made in Philadelphia, Franklin, and Somerset Counties, Pennsylvania, for the Committee on Meteorology of the Franklin Institute.

	PHILADELPHIA.—Lat. 39° 57′ 28″ N. Long. 75° 10′ 28″ W. Height above the sea 50 feet. Prof. J. A. KIRKPATRICK, Observer.								CHAMBERSBURG, Franklin Co. Lat. 39° 58′ N. Long. 77° 45′ W. Height 618 ft. WM. HEYSER, Jr., Obs.							SOMERSET, Somerset Co. Lat. 40° N. Long. 79° 3′ W. Height 2195 feet. GEO. MOWRY, Observer.						
1860.	Barometer.		Thermometer.			Force of vapor.	Relative humidity.	Rain.	Prevail'g winds.	Barom.	Thermom.		Force of vapor.	Relative humidity.	Rain.	Prevail'g winds.	Barom.	Thermom.		Force of vapor.	Relative humidity.	Rain.	Prevail'g winds.
Oct.	Mean.	Mean daily range	Mean.	Daily oscillation.	Mean daily range.	2 P.M.	2 P.M.			Mean.	Mean.	Mean daily range.	2 P.M.	2 P.M.			Mean.	Mean.	Mean daily range.	2 P.M.	2 P.M		
	Inch.	Inch.	°	°	°	Inch.	Per ct.	Inches.	Direc.	Inch.	°	°	Inch.	Per ct	Inch.	Direc.	Inch.	°	°	Inch.	Per ct.	Inch.	Direc.
1	30·150	·155	53·7	12	5·3	·361	86	0·230	S E.	29·456	52·3	4·3	·420	93	} 1·410	(var)	27·817	54·7	13·0	·537	100	0·705	(var.)
2	29·965	·184	69·0	21	15·3	·622	65		S W.	29·380	66·7	14·3	·606	77		N W.	27·802	64·7	1·0·0	·581	71	1·633	W.
3	30·119	·154	62·3	15	6·7	·380	52		N N E.	29·479	63·0	3·7	·509	74		E.	27·850	59·0	5·7	509	74		S.
4	30·036	·083	60·5	15	3·8	·468	73	0·020	(var.)	29·378	63·0	3·3	·562	94	0·100	S E.	27·762	63·0	4·0	·692	85	0·412	S
5	29·888	·147	65·5	14	5·0	·507	62	0·003	S W.	29·247	65·7	3·3	·608	80		W.	27·729	62·0	3·7	·488	62		W N W
☾ 6	29·987	·098	52·3	16	13·2	·202	48		N W.	29·361	55·7	10·0	·354	66		W.	27·743	51·0	11·0	331	63		(var.)
7	29·868	·171	51·5	22	8·5	·217	41	0·6·5	(var.)	29·2·8	51·0	7·3	·336	70	} 0·457	E.	27·580	58·0	12·3	·475	64	} 1·631	S W.
8	29·423	·445	61·0	22	9·5	·556	71	0·105	W.	28·804	59·0	8·0	·549	89		W.	27·278	55·0	8·3	·453	73		N W.
9	29·572	·149	51·8	13	9·2	·225	47		W N W	28·985	50·0	8·0	·468	60		W.	27·406	48·3	8·0	·281	58		W N W
10	29·728	·155	58·5	23	6·7	·301	42		S W.	29·054	56·7	4·3	·393	59		S.	27·444	55·0	6·7	·393	59		S W.
11	29·686	·067	63·7	16	5·2	·446	61		S W.	29·066	59·3	4·7	·498	70	0·147	S W.	27·484	52·0	8·3	·309	60		W N W
12	29·946	·259	52·2	15	11·5	·224	43	0·015	N W.	29·314	49·0	12·3	·207	53		(var.)	27·712	39·0	13·0	·175	50		N W.
13	30·042	·096	50·2	21	3·7	·187	40		(var.)	29·38·	47·7	2·0	·283	79		S W.	27·760	41·3	3·0	·180	43		N W.
● 14	30·026	·032	43·5	16	9·0	·234	70	0·706	N N E.	29·398	45·0	3·3	·283	79	0·180	(var.)	27·780	41·3	6·0	·204	68		N E.
15	30·043	·050	44·7	16	6·2	·231	64		(var.)	29·430	48·0	2·3	·295	68		(var.)	27·798	40·0	4·7	·209	58		W.
16	30·040	·053	49·0	21	4·3	·238	48		W S W	29·368	54·0	6·7	·296	59		(var.)	27·763	44·7	7·3	·216	46		(var.)
17	29·956	·084	53·8	23	4·8	·280	50		S S W.	29·266	46·3	7·7	·297	92	0·273	S E.	27·694	45·7	9·7	·278	81	0·100	(var.)
18	30·091	·135	58·0	19	6·2	·314	46		N E.	29·440	54·3	7·3	·439	88		S E.	27·797	45·0	5·3	·311	92	0·042	E.
19	29·961	·130	53·0	12	5·7	·252	52	0·200	N E.	29·324	52·7	1·7	·308	69	1·000	(var.)	27·712	47·7	2·7	·223	64	0·072	N E.
20	29·870	·105	53·7	5	2·7	·389	90	2·083	N E.	29·223	51·7	1·0	·348	86	0·514	S E.	27·574	49·3	3·0	·348	86	0·173	E.
☽ 21	29·821	·049	57·8	9	4·2	·455	88	0·075	N E.	29·144	57·7	6·0	·460	83		S E.	27·536	53·3	4·7	·369	66		E.
22	29·885	·064	59·0	11	1·5	·414	72		(var.)	29·244	61·7	6·0	·376	59	0·105	W.	27·658	50·3	3·0	·342	77		(var.)
23	26·790	·096	58·2	13	1·5	·339	57		S W.	29·143	58·0	5·7	·373	62		S W.	27·558	50·0	4·3	·351	70	0·024	W S W
24	29·813	·082	58·5	16	0·7	·296	48		S W.	29·202	57·3	3·0	·325	61		W.	27·611	50·0	4·7	·309	60		(var.)
25	29·918	·104	57·2	19	1·7	326	53		(var.)	29·251	54·7	5·0	·451	73		S W.	27·656	50·7	8·7	·345	54		S.
26	29·886	·032	60·7	21	3·5	·465	61		S W.	29·271	59·3	4·0	·385	52		(var.)	27·694	52·3	3·0	·362	55		(var.)
27	30·107	·221	52·8	18	7·8	·252	45		S W.	29·508	52·0	6·7	·538	65		S E.	27·819	52·0	1·7	·359	58		E S E.
28	30·198	·099	55·0	17	2·5	·315	58		E N E.	29·537	57·3	5·3	·443	82		(var.)	27·824	54·3	4·3	·376	69		E S E.
○ 29	30·104	·095	63·3	18	8·3	·507	74		(var.)	29·471	63·3	6·0	·509	74		N E.	27·804	56·7	5·0	·429	91	0·615	E S E.
30	30·074	·037	64·0	9	1·3	·625	95	0·337	S E.	29·426	65·3	2·0	·635	90	} 0·308	S E.	27·817	60·3	3·7	·458	76	0·052	E.
31	30·013	·062	67·3	11	3·3	·639	76	0·286	S E.	29·367	67·0	1·7	·644	85		S W.	27·770	61·0	2·0	·489	74		E S E.
Means	29·936	·119	56·8	16	5·8	363	61	4·685	s 70° w	29·294	56·5	5·4	·414	74	4·494	s 6° E	27·684	51·6	6·2	·366	68	5·439	s 53° w